THE UNIVERSITY OF MICHIGAN
JAN 12 1961
SCIENCE LIBRARY

THE QUARTERLY REVIEW OF BIOLOGY

QH
301
.Q2
Vol. 35
no. 3

SEPTEMBER
1960

Vol. 35 No. 3

Published by
THE AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES

© Copyright 1961
THE AMERICAN INSTITUTE OF
BIOLOGICAL SCIENCES

THE QUARTERLY REVIEW OF BIOLOGY

FOUNDED BY RAYMOND PEARL

BENTLEY GLASS, *Editor*
The Johns Hopkins University

DAVID R. EVANS
Assistant Editor

Editorial Office:
Department of Biology, The Johns Hopkins University,
Baltimore 18, Maryland

Advisory Board

G. W. BEADLE.....*California Institute of Technology*
DAVID R. GODDARD.....*University of Pennsylvania*
LIBBIE H. HYMAN.....*American Museum of Natural History*
K. S. LASHLEY.....*Harvard University*
DANIEL MAZIA.....*University of California*
CHARLES W. METZ.....*University of Pennsylvania*
THOMAS PARK.....*University of Chicago*
ALFRED S. ROMER.....*Harvard University*
F. O. SCHMITT.....*Massachusetts Institute of Technology*
PAUL WEISS.....*Rockefeller Institute*
B. H. WILLIER (Emeritus Editor).....*Johns Hopkins University*

Papers to Appear in an Early Number

ANIMAL VIRUSES AND EMBRYOS
James D. Ebert, *Carnegie Institute of Washington* and
Fred H. Wilt, *Purdue University*

A GENE CONCEPT BASED ON GENETIC AND CHEMICAL STUDIES IN NEUROSPORA
Dow O. Woodward, *Brooks Air Force Base, Texas*

Second class postage paid at Baltimore, Maryland. Published quarterly at Mount Royal and Guilford Aves., Baltimore 2, Md., by the American Institute of Biological Sciences, Business Office, 2000 P Street, NW, Washington 6, D. C. Subscription price, $10.00 a year ($8.00 to members of AIBS; $10.75 outside U.S.A., except Canada. Canada, $10.25). $2.75 a single copy, when available, $.25 postage outside U.S.A.

Made in United States of America

VOL. 35, NO. 3 September, 1960

THE QUARTERLY REVIEW *of* BIOLOGY

SOVIET AQUATIC BACTERIOLOGY: A REVIEW OF THE PAST DECADE

BY JOHN McNEILL SIEBURTH

Narragansett Marine Laboratory, University of Rhode Island, Kingston

ABSTRACT

The importance of bacteria in oceans and lakes is slowly gaining recognition. The post-war Soviet studies on the Black Sea have led to the development of techniques which are being used in the "complex studies" being conducted on virtually all major water bodies of the world. These investigations, which are primarily concerned with the productivity of water basins, have led to some very interesting observations from "pole to pole." Included are studies such as the bacterial development in the region of the North Pole, chemosynthesis in water reservoirs, and the use of bacteria as hydrological indicators of Antarctic water masses. The purpose of this review is to draw attention to and discuss the nature and extent of Soviet work in aquatic bacteriology.

INTRODUCTION

DURING the past few years Soviet progress in the collection of sciences known as oceanology has drawn much attention. One of the contributing sciences, aquatic bacteriology, has often been overlooked despite the fact that bacteria to some extent affect, control, or perpetuate many chemical, physical, and biological processes in water bodies. Russian literature in this field until recently has been generally difficult to obtain and often overlooked. The growing number of foundation-sponsored translations, lists of accessions, and translations, as well as the incorporation of *Referativnyy Zhurnal—Biologiya* into *Biological Abstracts*, makes much of the current literature available. The purpose of this review is to draw together the scattered literature of the last decade and to discuss the nature and extent of Soviet work.

Before considering the scientific aspects of the Soviet studies one should understand the rationale behind them in order to appreciate why emphasis has been placed on bacterial productivity. Systematic investigations on the Black Sea were conducted by members of the Institute of Microbiology (Moscow) and the Sevastopol Biological Station (Black Sea) during the years 1946 to 1951. The purpose of these studies was to determine the horizontal and vertical distribution of microorganisms in both the oxygen and hydrogen sulfide zones, to characterize quantitatively the various bacterial processes, and to estimate the significance of bacteria in the nutritive chain (Kriss, 1954a). The Black Sea studies were a forerunner of the "complex studies" now being conducted on nearly every major water body. These "complex studies" arose out of the directives of the Nineteenth Congress for the Fifth Five Year Plan (1951–1955) which called for increased activity in the fishing industry and led to programs in all collateral fields including aquatic bacteriology (Kriss, 1954b). Certain marine aspects of these studies, especially those by the Institute of Microbiology, are comprehensively compiled in the monograph by Kriss (1959a).

FIG. 1. THE INSTITUTE OF MICROBIOLOGY OF THE USSR ACADEMY OF SCIENCES IN MOSCOW
(Photo by Dr. Carl H. Oppenheimer)

METHODOLOGY

For the most part the Soviet workers have used standard bacteriological methods. However, a few procedures have been developed to facilitate the studies on bacterial populations and their rate of multiplication. These commonly used procedures will be discussed here while other techniques will be mentioned in the discussion of the individual papers.

The enumeration of viable bacterial populations in a natural habitat poses many problems. These are due mainly to the varying nutrient and environmental requirements of the component species and the chaining and clumping of bacterial cells. Media and procedures have not yet been developed to overcome these problems. However, the development of small porosity membrane filters which retain bacteria has greatly aided the enumeration and study of water samples. Razumov (1955), who has been a pioneer in this field, has reviewed both the Russian and American filter types, filter apparatus, procedures, and their applications.

Membrane filter plate counts have been used in addition to, or in place of, agar pour plate counts. The filters which retain the bacteria from the filtered water sample also permit nutrients, from agar media or broth-soaked filter paper pads upon which they are placed, to reach the surface where bacterial colonies develop. Kriss, Rukina, and Biriuzova (1951b) found that the advantage of this method was that significant numbers of bacteria for counting purposes could be obtained by using 25 to 40 ml aliquots of water samples low in bacteria, whereas the customary 1 ml used to inoculate agar pour plates often yield no bacteria. Rukina and Tikhonenko (1952) compared the membrane filter and pour plate methods and also found that the membrane filter procedure was suitable in this instance. These authors found that in water samples which were rich in bacteria, antagonistic effects and coalescence of colonies made the membrane filter method inferior to the plating method. Better results were obtained at the Scripps Institution by Jannasch and Jones (1959), who examined their plates microscopically for "microcolonies" at more frequent intervals.

Cultural procedures ordinarily indicate only a tenth to one per cent of the total number of bacterial cells detected microscopically in the aquatic habitat. In an attempt to overcome the disadvantages of cultural procedures for the enumeration of bacterial populations, direct microscopic methods have been used. Membrane filters are uniquely suited for this application and membrane filter direct counts have been used to a great extent by Soviet investigators. In this procedure a suitable aliquot of the water sample is filtered, the filter is fixed in formalin vapors, and then stained with erythrosin and dried. The filter is then clarified with Canada balsam and a cover slip is applied. After counting the bacteria in a certain number of ocular grids, the number per ml are calculated by a suitable formula. Kriss, Lebedeva, and Rukina (1952) found that the resident bacteria in commercial membrane filters could cause serious errors in water samples with low bacterial populations, making them unsuitable for this type of work. In order to overcome this objection Rukina and Biriuzova (1952) prepared bacteria-free membrane filters for microscopic work. Razumov (1955) considered that counts made on the stained rim of the filter, which does not come in contact with the sample being assayed, served as an adequate control.

Direct microscopic counts on bottom sediments have usually been made using a modification of Winogradsky's (1928) method which was developed for the study of soils. The usual objection to direct microscopic procedures is that dead cells are also enumerated. However, Kriss and others using these procedures feel that dead cells could not account for more than ten per cent of the population, because dead cells are rapidly autolyzed under natural conditions.

The studies on productivity have used fairly standard procedures which were developed during the early studies on soil and water bacteriology. These have been modified and applied as routine analytical tools. In order to estimate the bacterial biomass, the total number of cells (determined by direct microscopic counts), calculated mean cell volume, and assumed density are used to estimate the weight of bacterial cells in a cubic meter of water or a square meter of bottom sediment. The bacteria in bottom sediments are expressed on an area basis, since they are concentrated in a thin layer extending only a few millimeters below the mud-surface interface. In addition to bacterial biomass estimates, the rate of multiplication is also essential for productivity measurements. Two methods have been used for determining the rate of multiplication of aquatic bacteria in situ: Ivanov (1955) developed an isolated sample technique for measurements on reservoirs. Filtered and unfiltered water samples were placed in glass-stoppered bottles and returned to the depth from which they were obtained for incubation. Initial and final bacterial populations and the time of incubation were used to determine biomass, generation time (filtered to remove zooplankton), and net production (unfiltered with original zooplankton population).

The second method for determining the rate of multiplication is an application of the time-tested "buried slide technique" developed by Cholodny (1930). This technique was applied to fresh water by Henrici (1933) and by Karzinkin (1934), and to salt water by ZoBell and Allen (1933). The basis of the "submerged slide technique" is that aquatic bacteria settle onto the surface of immersed glass slides where they adhere and multiply to form microcolonies. The classic study by Henrici (1936) apparently laid the groundwork for the application of this method to the estimation of bacterial multiplication in situ by Kriss and colleagues (Kriss and Rukina, 1952a; Kriss and Markianovich, 1954; Kriss, Biriuzova, and Rukina, 1954). The number of microcolonies and the number of cells per microcolony developing on the slide are used along with the time of immersion to estimate the multiplication rate. Among the disadvantages of this technique are that only certain species (ZoBell, 1943) and strains (Zvyagintsev, 1959) have the ability to adhere to glass slides. In addition, the time of immersion is very critical since the settling out and multiplication rate decrease with time (Kriss and Rukina, 1952a; Henrici, 1936), presumably as a result of mutual antagonism. However, Kriss and Markianovich (1954), who have discussed the various advantages and disadvantages of this method, feel that it is superior to the isolated sample method of Ivanov (1955). The submerged slide method as used by Kriss for measuring the rate of bacterial multiplication was analyzed statistically by Ierusalimsky (1954) who developed formulas for its use. The average rate of multiplication (R_{av}) on a glass slide was represented by $R_{av} = 4 \Sigma \log m/Nt$. The value m was the number of cells in all colonies, N the number of points of growth regardless of whether single cells or colonies, and t the time of immersion of the glass slide. In addition to the rate of multiplication the "coefficient of growth" (B) was used to show the relationship between multiplying and nonmultiplying cells. In the equation $B = 100\ k/k + 0$, the value k is the number of colonies and 0 is the number of single cells. A large num-

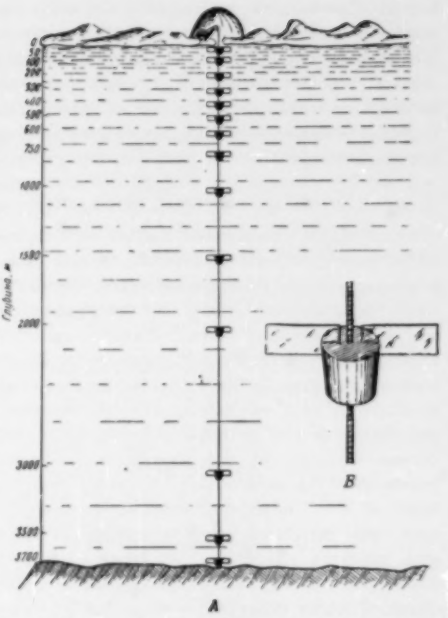

FIG. 2. DIAGRAM ILLUSTRATING THE "SUBMERGED SLIDE" TECHNIQUE WHICH HAS BEEN APPLIED BY DR. KRISS AND COLLEAGUES TO DETERMINE THE RATE IN SITU OF BACTERIAL MULTIPLICATION IN MARINE BASINS (Figure from Kriss, 1959a)

ber of observations are required in order to overcome the inherent errors of the method. The data are also expressed as Zenkevich's (1951) coefficient of productivity, P/B, which indicates in this application the daily rate of increase in bacterial biomass as a percentage of the standing bacterial biomass.

DISTRIBUTION OF BACTERIAL POPULATIONS

Innumerable interrelated factors such as salinity, nutrients, hydrogen sulfide, climate (temperature, storms, illumination, etc.), depth of water, distance from shore, and the production and decomposition of plant and animal material cause an uneven micro- and macro-zonal distribution of aquatic bacteria. Before the bacterial productivity of a water basin can be estimated, the distribution of bacterial populations in the various horizons of the neritic and oceanic provinces of the water mass must be determined. Most of the studies on bacterial distribution have not correlated the bacteriological data with physical, chemical, and other biological observations to any extent. Those that have are discussed under ecological studies and bacteriological processes.

Black Sea

During the 1946 Black Sea Expedition, Kriss and Rukina (1949a) made agar plate counts on water, sediment, and plankton samples in order to obtain the vertical and horizontal distribution of numbers as well as individual species of bacteria. Although the inadequacies of this cultural method were realized, the authors felt it was more important to study the bacterial types than to study the exact quantities at this stage of the investigation. The plankton zone (upper 100 m layer) and sea bottom were rich in bacterial life compared to the horizons between, which had low bacterial counts. Sporadic high counts were attributed to sinking plankton that was undergoing decomposition. Their results indicated that the number of different microbial types decreased from the oxygen zone (52 bacterial types) to the hydrogen sulfide zone (28 types) to the bottom sediments (18 types). This simplification of the microflora with depth was explained by experiments on the oxygen requirements of these 52 bacterial types. Forty were obligate aerobes while twelve were facultatively anaerobic and could grow well under the anaerobic conditions of the hydrogen sulfide zone.

Membrane filter plate counts on fish peptone agar obtained during the 1946, 1948, 1949, and 1950 Black Sea expeditions were used by Kriss, Rukina, and Biriuzova (1951b) to illustrate the microzonal distribution of heterotrophic microorganisms. The non-uniform distribution of bacteria in microzones, reported in the preceding paper, was confirmed. Microorganisms occurred more abundantly in the oxygen zone than in the hydrogen sulfide zone. Use of the membrane filter technique permitted the assay of larger volumes and eliminated the "sterile" samples noted previously. However, in samples rich in bacteria, these authors noted lower values by this procedure than from pour plates. These authors remarked that they did not observe the characteristic abundance peak at a depth of 50 to 75 m reported by ZoBell (1946). However, in the following and later papers Kriss has shown this peak for the Black Sea (Kriss, Lebedeva, and Rukina, 1952) and other water bodies (Kriss, Biriuzova, and Rukina, 1954). The distribution of heterotrophic organisms in the Black and Okhotsk Seas was investigated by Kriss, Rukina, and Novozhilova (1952). The data on water samples from different depths consisted mainly of comparisons of counts on various plating media, broth, and membrane filters. The effect of the size of the water sample on the counts obtained with filters was also determined. The low counts and inconsistent use of media between stations make the evaluation of these results quite difficult. Pooled data were used to show the frequency distribution of heterotrophs at 22 water depths from 0 to 4,800 m. From these data, the authors reported that the macrozonal distribution of bacteria was: at least 30 or more per liter at most water depths; more than 100 per liter at the surface and at 150 to 200 m; while in areas where organic matter on the surface was rich, counts of several thousand per liter were obtained at depths up to 2,000 to 3,000 m. This association of the heterotrophic microflora with organic matter from the phyto- and zooplankton was also shown in the microzonal distribution from horizon to horizon and within the same sample. Individual species capable of decomposing the "water humus" were found at all depths.

During the 1950 studies on the Black Sea,

membrane filter direct counts were made in addition to the membrane filter plate counts reported above. These were used to illustrate the vertical distribution at various distances up to 60 miles from shore (Kriss, Lebedeva, and Rukina, 1952). The greatest concentration of microorganisms was at a depth of 50 m and the number generally decreased with depth and distance from shore. Following the adoption of direct count procedures in the preceding paper, a series of studies on various oceans was conducted in which only direct count data were obtained. Such a paper on the Black Sea is that by Kriss and Lebedeva (1953). The various morphological types and the vertical distribution of their biomass in the hydrogen sulfide zone was reported. Alfimov (1954) compared the direct count and plate count methods in an evaluation of these procedures for the detection of pollution in a harbor area of the Black Sea. Direct counts were believed to be a more reliable index of bacterial content, since they correlated with the sanitary observations and gave high values when the bacteria in the plate counts were apparently inhibited.

The presence of yeasts in aquatic environ-

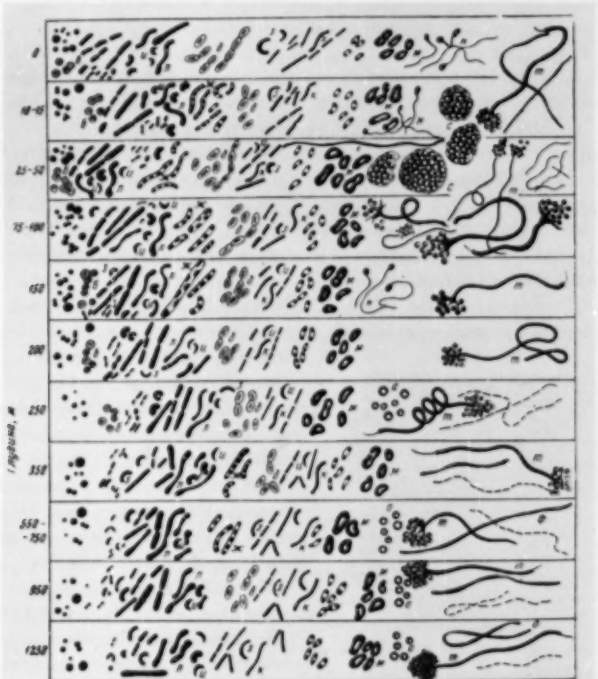

FIG. 3. THE VERTICAL DISTRIBUTION OF DIFFERENT MORPHOLOGICAL FORMS OF MICROORGANISMS IN THE BLACK SEA
(Figure from Kriss, 1959a)

ments has long been recognized (Fischer, 1894), but these organisms have often been regarded as oceanic transients. Although they are usually present in much smaller numbers than bacteria, their relatively large size may make them more useful as food for aquatic animals. During the 1950 Black Sea studies membrane filter plate counts for yeasts were conducted (Kriss, Rukina, and Tikhonenko, 1952). Achromogenic, pigmented, and fungal forms were found at most depths in small numbers (less than one per milliliter). Various yeast species were found widely distributed with regard to depth and distance from shore. Yeasts have also been found widely distributed in other water basins, and budding forms were observed at a depth of 3,000 m in the Arctic Ocean by Kriss (1955a).

For a review of the bacteriological studies on the Black Sea the reader is referred to the article by Kriss (1954a). The findings and conclusions of the above studies by Kriss and co-workers were used to show the significance of bacteria in the biological productivity of this water body. Topics discussed were: vertical distribution of organic particles, distribution of heterotrophic microorganisms, nature of microbial physiological properties, total population and microbial biomass, and mineralization and synthesis.

Arctic Ocean

Bacteriological studies on the Arctic Ocean were conducted as early as 1908 by the father of Russian marine bacteriology, B. L. Issachenko (1914, 1951). Kriss's interest in the Arctic dates back to the 1938 expedition to Wrangel Island and adjacent areas in which the number and species of microorganisms in the soil of tundras, sea water, and bottom sediments were studied (Kriss, 1947). Russian proximity to and interest in this geographical area has led to a series of "complex studies" conducted mainly since 1954. The nature and extent of these studies in many fields of science were briefly reviewed in the English language Soviet publication *New Soviet Discoveries in the Arctic* by Burkhanov (1956). Flights to the various ice islands during the Arctic summers of 1954, 1955, and 1956 gave Kriss and colleagues an opportunity to conduct bacteriological studies in the central Arctic Ocean. The hydrological tent served as the laboratory and housed a hole in the ice through which the samples were obtained. Data were obtained by the use of submerged slides, direct counts, and plate counts. These investigations have been the subject of at least seven papers and have provided information for a number of others.

The first and probably most comprehensive of the Arctic studies was conducted from drifting station "North Pole 3." The approximate position of this ice island during July was 88° N, 151° W and during September was 89° N, 65° W. Data on water samples taken to depths of 3,500 to 4,000 m and on bottom sediments were reported (Kriss, 1955a). Membrane filter direct microscopic counts and membrane filter plate counts demonstrated bacterial life at all depths. The direct count data demonstrated more morphological types (especially cocci with thick walls) and 100 to 1,000 times more organisms than the cultural method. In comparison with similar data from the Pacific Ocean, the Arctic Ocean contained only one-tenth or less the population in the upper layers, while the differences became smaller with depth. The usual morphological types decreased with depth, while the cocci with thickened walls were uniformly distributed except for the surface layer where they were less plentiful. Six media, used to detect and enumerate heterotrophic, nitrifying, denitrifying, and sulfate-reducing bacteria in the bottom sediments, indicated concentrations of 200 bacteria or less per gram of mud. Direct counts on these sediments ranged from 4 to 304 million per gram.

The 1954 data from "North Pole 3" have been reported in many forms. The vertical distribution of numbers (plate and direct counts), biomass, and morphological types were again reported by Kriss, Biriuzova, Tikhonenko, and Lambina (1955). Kriss and Lambina (1955) used the submerged slide data to calculate the vertical distribution of the total number of bacteria growing on the slides and the number of each morphological type at each depth. Abundance peaks at certain depths observed by this method were similar to those shown by the direct count method reported below. In addition, the total and daily increases in bacterial biomass were reported. A comprehensive account of the popular and technical aspects of this same 1954 study at "North Pole 3" was given by Kriss (1955b). The presence of assimilable organic material in isolated water samples was indicated by an increase

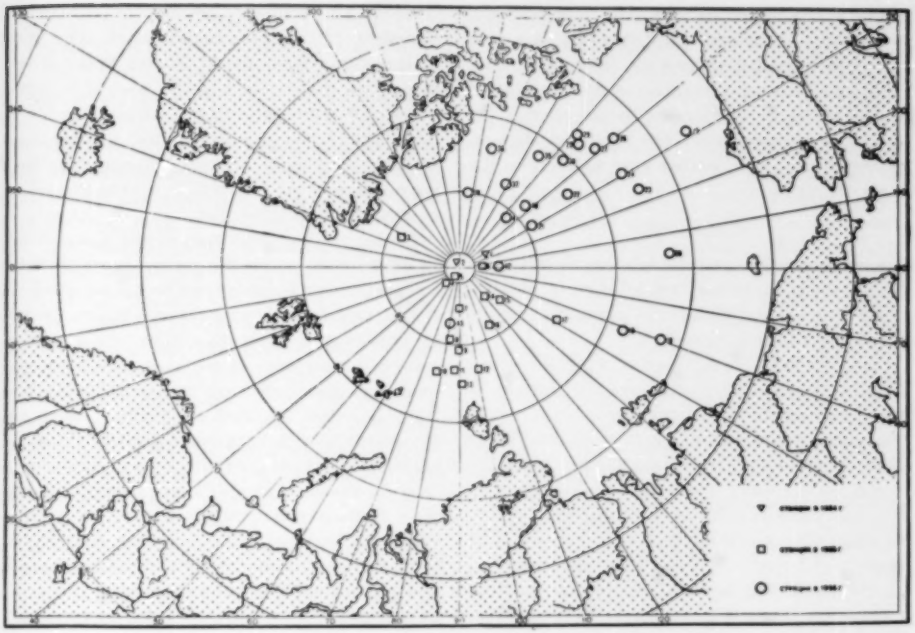

FIG. 4. THE LOCATIONS OF MICROBIOLOGICAL STATIONS IN THE CENTRAL ARCTIC DURING THE 1954, 1955, AND 1956 INVESTIGATIONS
(Figure from Kriss, 1959a)

in bacterial counts. The occurrence of yeasts at various depths and an unusual form which was later given new class status (Kriss and Mitzkevich, 1957) were pictorially recorded. Peaks of bacterial numbers were found at depths of 200, 1,000, and 2,000 m and were interpreted as an indication of interfaces of different water masses.

The methods used to obtain submerged slide data, membrane filter plate counts, and direct counts on water samples from fifteen vertical stations and mud cores at three stations during the 1955 Arctic studies were given in detail by Kriss (1955c). However, only data on direct counts from two stations and slide overgrowth from one station were presented to illustrate the vertical distribution of microorganisms.

The Arctic Ocean studies conducted in 1956 were reported by Kriss (1957). Locations of 43 microbiological stations were given by both a table and a map despite the fact that the single table of data reported information from only 2 of these stations. These new data consisted of 12 colonies that developed on 7 out of 78 agar

FIG. 5. INTERIOR VIEW OF HYDROLOGICAL TENT ON AN ARCTIC "ICE ISLAND" SHOWING SAMPLING HOLE, WINCH, AND SAMPLERS. THE TENT ALSO SERVED AS A FIELD LABORATORY FOR BACTERIOLOGICAL STUDIES
(Photo from Burkhanov, 1956)

plates. Kriss explained that the low bacterial population, compared with previous data, was due to seasonal factors and the Atlantic current. Although direct microscopic studies conducted at 25 stations were described in great detail, the data were not presented. The combined data reported in the above studies were summarized by Kriss (1958).

Caspian Sea

Studies on the Caspian Sea have concerned mainly the distribution and biomass of bacteria in the water and sediments and the effect of the Volga River inflow upon them.

Zavarzin (1955) conducted a study in which the distribution of bacteria and the content of dissolved oxygen were determined in the upper seven centimeter layer of water in various basins of the Volga delta. Direct microscopic and plate counts on the surface, subsurface, and one, two, five, and seven centimeter depths indicated that bacterial films could occur on the surface. The number of bacteria in these films approximated the estimated number of cells required to form a 0.002 cm layer. When present, this bacterial film caused a marked decrease in the concentration of dissolved oxygen in the subsurface (zero to one centimeter) layer.

A number of studies on the northern part of the Caspian Sea have been conducted by Osnitskaia of the Institute of Microbiology. Bottom sediments were cultured to determine the distribution and numbers of autotrophic and heterotrophic microorganisms (Osnitskaia, 1953). Sulfate-reducing bacteria occurred in 100% of the samples but in low numbers, since dilution resulted in less than 3% positive samples. Hydrogen- and methane-oxidizing bacteria were present in 60 to 70% of the one gram samples, while putrefactive bacteria occurred in 49% of the samples studied. Although a bacterial film as such was not found on the bottom sediment, the different physiological types were widely distributed in the sediment at different water depths and locations. In order to determine the distribution and biomass of microorganisms in the water strata, direct counts on membrane filters were made on samples from 138 deep and shallow water stations (Osnitskaia, 1954). Bacterial numbers were found to be greatest in the shallow waters and at the influx of the Volga. The bacterial population decreased as both the depth and distance from the Volga delta increased. The influence of biogenetic material, plankton, and salinity was discussed. The effect of the influx from the Ural and Volga Rivers during the flood stage was also studied by direct counts on membrane filters (Osnitskaia, 1956). The bacterial population in the shallow areas of the Volga delta increased during the flood stage and reached a maximum during the period of maximum plankton blooms.

Studies on the same area of the Caspian Sea by other investigators are essentially similar and in agreement with those of Osnitskaia. Zhukova (1955) criticized the earlier qualitative studies by Osnitskaia (1953) and others which demonstrated the presence of methane- and hydrogen-oxidizing, nitrifying, and sulfate-reducing bacteria. Zhukova felt that the primary need was for quantitative data in order to characterize the bacterial processes and the role of bacteria as food for invertebrates. Zhukova used Winogradsky's direct count method in order to characterize the bacterial biomass on the basis of the estimated cell volume of the predominant coccal and rod forms. The most important factors influencing the numbers (5.7×10^7 to 1.2×10^{10} per gram of wet sediment) were considered to be the organic matter which varied with the flood conditions of the Volga and the physical nature of the bottom sediments. The effect of the inflow of the Volga on the number of bacteria in the bottom sediments was also determined by Lambina (1957) who used the Winogradsky method. She also found the inflow of the Volga River water and its accompanying organic matter to be the main factor influencing the number of bacteria. The zones of different bacterial concentrations were charted. The maximum concentrations occurred in areas where the currents formed anti-cyclonic vortices. However, one should note that the range of the seven concentrations plotted on the maps were within one log place (3 to 30×10^6). Lambina states that similar studies on the influence of seasonal factors have not been conducted on microorganisms in marine sediments despite the above-mentioned paper by her colleague at the same institute, Osnitskaia (1956), and that by Nikitina (1955b) which is discussed in the section on ecology.

Studies conducted by Kriss and associates on the Caspian Sea were summarized by Kriss (1956a). These studies were conducted during the 1952 VNIRO (All-Union Scientific Institute

of Fishing and Oceanography) Expedition to the southern and central Caspian (Kriss, Biriuzova, and Rukina, 1954). Since earlier studies in this region had concentrated on the bottom sediments, 220 water samples from 31 stations in four cross-sections of the neritic and oceanic zones were studied by means of membrane filter direct counts and submerged slides. The vertical distribution of bacteria, expressed as both numbers and biomass, indicated similar concentrations in the 0 to 10, 0 to 25, and 0 to 50 m layers (36 to 39 mg/m^3), and approximately one-sixth this value from 50 m to the bottom. Submerged slides were used to determine that the mean time for cell division of the bacteria adhering to the submerged slides was 48 hours. The predominant forms were bacilli, while cocci predominated only in some horizons at a few stations. Other forms observed were filaments, sarcina packets, and yeast-like forms.

Okhotsk Sea and Adjacent Areas

The Okhotsk Sea and the adjacent areas in the northwestern part of the Pacific Ocean have been the subject of a number of studies. Kriss and Rukina (1952a) conducted direct microscopic studies on 200 water samples obtained at depths of 0 to 4,800 m from 12 stations on the Okhotsk Sea. Membrane filter direct count and submerged slide data were used to determine the number, biomass, and rate of multiplication of the bacterial population. The vertical profile of the sea was divided into four zones on the basis of the density of the bacterial population. These were: zone one, an area of bacterial maxima in the photosynthetic zone from 0 to 25–35 m; zone two, an area of bacterial minima from 25–35 m to 75–100 m; zone three, an area of bacterial maxima in the zooplankton zone from 75–100 m to 250–500 m; and zone four, an area of bacterial minima from 250–500 m to the bottom. Unlike the other bacterial forms which predominated in the upper water layers, the cocci with thickened walls which could not be cultivated on artificial media occurred in greater numbers in the deeper water layers.

Kriss and Rukina (1952b) obtained sediment samples from nine stations in the same area of the Okhotsk Sea; these were divided into 50 specimens representative of the different horizons of the cores. The bacterial population was enumerated by Winogradsky direct counts and cultivation on a number of broth and agar media for heterotrophic and autotrophic bacteria. Cultivable microorganisms occurred in concentrations of 10^4 per gram on the surface but could not be detected below a depth of 155 cm. Total counts on the same material were as high as 10^8 per gram. The direct count data indicated that the bacillary forms decreased with depth while the cocci with thick walls, which have been previously mentioned, increased with core depth and were present in appreciable numbers (10^6 per gram) even at depths of 32 m. The results of previous investigations on oceanic sediments (four German, four American, and one Russian) were discussed. This is interesting in view of the later discussions by Kriss in which he says that most non-Russian investigations have been mainly concerned with studies on the euphotic and littoral zones.

Quantitative analyses of bacteria in water and bottom samples from the Pacific Ocean southwest of Kamchatka conducted in 1946 were reported by Limberg-Ruban (1952). During the 1953 cruise of the *Vitiaz* in the Pacific Ocean, Kriss and Biriuzova (1955) characterized the vertical distribution of bacteria in the Kuril-Kamchatka depression by plate and direct counts on membrane filters. Although most of the 35–40 ml samples yielded no detectable colonies, sporadic high counts (up to 100 per plate) were irregularly distributed to depths of 7000 m. Non-sporeforming bacilli were the predominant bacterial type cultivated. The high counts in the deep water samples were attributed to either interfaces of different water masses or to deep currents. The microscopic data which demonstrated 100 to 1,000 times as many organisms as the plate counts were again used to divide the water into different horizons on the basis of bacterial density. Microcolonies of up to 100 cells were observed in the surface layer.

A popular account of the 1951 studies on the Okhotsk Sea (Kriss and Rukina, 1952a, 1952b) and the 1953 study on the Pacific Ocean (Kriss and Biriuzova, 1955) discussed above were given by Kriss (1955d). The spacious laboratory aboard the research vessel, *Vitiaz*, which has been called the "floating institute," was described. The value of membrane filters and immersed slides for the calculation of total numbers and biomass was emphasized and compared with membrane filter plate counts. The 1953 studies by Kriss and Biriuzova (1955) on samples from depths of

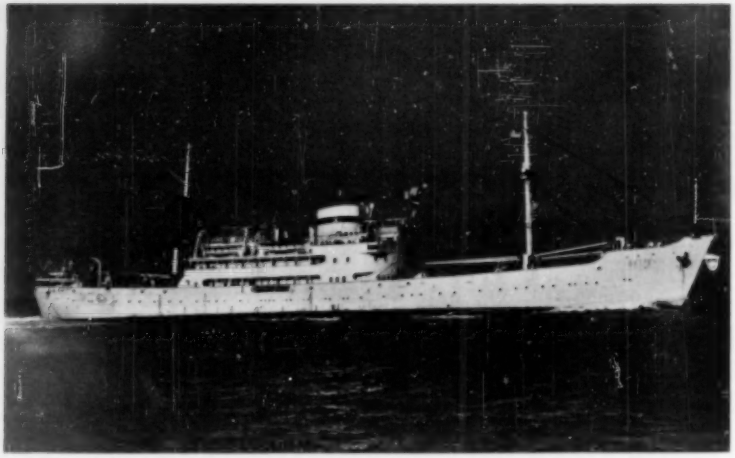

FIG. 6. THE RESEARCH VESSEL *Vitiaz* OF THE USSR INSTITUTE OF OCEANOGRAPHY

6,000 to 9,000 m in the Kuril-Kamchatka depression were said to be "the first microbiological investigation of ocean water at this depth" (Kriss, 1955d). However, ZoBell (1952) had studied the bottom sediments exceeding 10,000 m in depth in the Philippine Trench in 1951. This report was reviewed by Zenkevich (1953) who discussed the importance of the rich bacterial flora in bottom sediments to the benthic zoopopulation.

Agar plate counts of bottom sediments from the Bering Sea were obtained by Rozenberg (1954) in order to make quantitative estimates on samples from various water depths. Only small numbers were obtained by this method. In a later study Rozenberg (1958) presented a statistical analysis of the zonal distribution of heterotrophic bacteria in the 100 m surface layer which was determined during the 1956 cruise of the *Vitiaz* in the Okhotsk, Bering, and Japanese Seas, and the northwestern Pacific Ocean. The bacterial content which was quite low in the Bering Sea (88% of samples contained two cells/ml or less) increased progressively in the Okhotsk Sea, Sea of Japan, and Pacific Ocean. The maximum numbers of bacteria were found between 20° and 30° N. At 42° N there was a sharp line of demarcation between the northern zones of lower content and the southern zones of higher content.

Southern Oceans

Increased activity in Antarctica as a result of the IGY has taken a number of Soviet ships, especially the reinforced diesel electric ship *Ob*, into southern marine basins. Lebedeva (1958) described preliminary results on the vertical distribution of heterotrophs between Antarctica, India, and Africa. Twenty-four horizons at depths from 0 to 5,700 m were sampled. Four profiles representing antarctic, subtropic, and tropic waters of the Indian Ocean were given. Fifty-six per cent of the 693 samples cultured contained only one or no viable bacteria per 40 ml of sample. Although there was a greater bacterial concentration above 50° S latitude, there was no detectable correlation between numbers and temperature or oxidizable substrate. These data evidently have been the basis for the interesting application of heterotrophic organisms as hydrological indicators of different water masses by Kriss (1959a, 1959b). Profiles of bacterial concentrations covering all depths from the high latitudes across the equator have shown the penetration of the low bacterial content Antarctic water masses into the Indian and Pacific Oceans. This bacteriological extension of the principle of biochemical geography (Hutner, Provasoli, McLaughlin, and Pintner, 1956) may find additional applications.

BIOMASS AND PRODUCTIVITY

Biomass, which is an expression of the population and is usually expressed on a weight per volume or area basis, characterizes the standing crop only and tells nothing about the productivity of the area. Productivity, which charac-

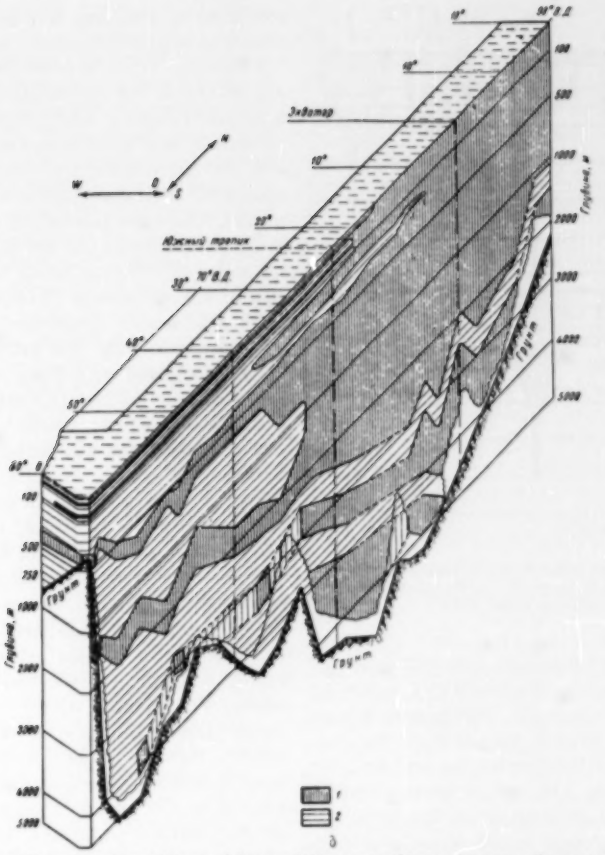

FIG. 7. A CROSS SECTION OF THE WATER MASS IN WHICH THE HETEROTROPHIC BACTERIAL CONTENT IS USED AS AN HYDROLOGICAL INDICATOR TO SHOW THE MIXING OF COLD ANTARCTIC WATERS WITH THE WARMER AND RICHER WATERS FROM THE INDIAN OCEAN
(Figure from Kriss, 1959a)

terizes the fertility, is much more difficult to ascertain. The term "primary productivity" has been used to denote the phytoplankton blooms that are considered to be the basic link in the food chain for aquatic animals. However, Soviet bacteriologists suggest that the mass and reproductivity of bacterial cells is appreciable and under certain conditions may equal or exceed the productivity of phytoplankton. Many of the papers of the last decade deal either directly or indirectly with this concept of biomass or its application.

The biomass of microorganisms in the surface layers of bottom sediments in the hydrogen sulfide area of the Black Sea was estimated by Kriss, Rukina, and Tikhonenko (1950). On the basis that the volume of one cell equals one μ^3 and that the density is unity, the biomass was calculated to be 15 to 30 g/m^2. This value was considered to equal that of the microbiomass in the productive northwestern part of the sea and to exceed several thousand fold the yearly production of zoo-benthos. The productivity of the oxygen zone (0 to 200 m) of the Black Sea was estimated by Kriss, Lebedeva, and Rukina (1952). Measurements on 500 bacilli and cocci gave an average volume of not 1.0 μ^3 but 0.2 μ^3. On the assumption that the annual coefficient of P/B was equal to that of the Pacific Ocean (1,022), a yearly production of 15 g of bacterial biomass/m^2 was estimated. In a subsequent paper on Black Sea productivity (Kriss and Markia-

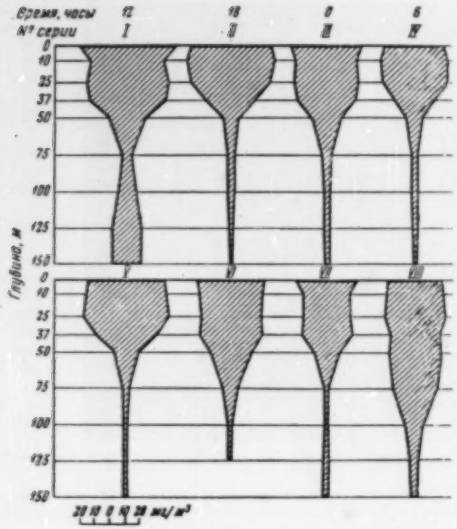

FIG. 8. A PROFILE SHOWING THE DISTRIBUTION OF BACTERIAL BIOMASS IN THE BLACK SEA (figure from Kriss, 1959a)

novich, 1954) the submerged slide technique was used to calculate the mean daily P/B according to Ierusalimsky's formula. Preliminary results indicated a P/B of 13% for the Black Sea compared to 35% for the Caspian Sea and 80% for the Pacific Ocean. The role of microorganisms in the biological productivity of the Black Sea was discussed at length in the review article by Kriss (1954a).

The productivity of the central and southern parts of the Caspian Sea was calculated by Kriss, Biriuzova, and Rukina (1954). Assuming an average cell volume of 0.2 μ^3 and a density of unity, the mean biomass for all horizons was 20.8 mg/m^3 and 35 mg/m^3 for the photosynthetic zone (0 to 50 m). The mean generation time was 48 hours and the mean daily P/B coefficient was 0.35 or 35%. These values were used to estimate that 1.2 mg/m^3 or 0.1% of the reported total organic matter (12 mg/m^3) in the photosynthetic zone were mineralized daily. This represented a daily regeneration of 0.5 mg of nitrogen and 0.2 mg of phosphorus per m^3 of water. The biomass in the region of the Volga delta was estimated by Osnitskaia (1954) to range from 470 to 600 mg/m^3 of water and sometimes reached 750 mg/m^3. The bacterial biomass of the bottom sediments in this area was estimated to range from 2 to 50 g/m^2 (Zhukova, 1955).

Productivity data were calculated for the various depths of the central Arctic (Kriss, 1955b; Kriss and Lambina, 1955). Population and multiplication were greatest at the surface, 1,000 m and 200 m, respectively. The biomass varied from 0.007 mg/m^3 at 3,500 m to 8 mg/m^3 at the surface. The daily increase in bacterial biomass ranged from 0.0008 in the deep water to 4.5 mg/m^3 at the surface which represented daily P/B coefficients of from 12 to 72%. The amount of organic matter mineralized per day in the photosynthetic zone was estimated to be 1.3 mg/m^3 compared to 6.5 mg/m^3 for the Black Sea (Kriss, 1954a) and 11.2 mg/m^3 for the Caspian Sea (Kriss, Biriuzova, and Rukina, 1954).

The Okhotsk Sea was the source of data used by Kriss and Rukina (1952a) to outline not only the procedures but the advantages and shortcomings of the methods used to study bacterial productivity. The biomass of vertical profiles to a depth of 4,800 m ranged from 0.001 mg to 1.0 mg/m^3 with a mean of 0.1 mg/m^3. The mean annual production of bacteria at all depths was calculated to be 100 mg/m^3 which would mineralize 6 to 15% of the total organic matter yearly. The biomass of the bottom sediments ranged from 0.2 to 1.4 g/m^2 (Kriss and Rukina, 1952b). Biomass values for the region of the Kuril-Kamchatka Trough of the Pacific Ocean ranged from 0.006 to 81 mg/m^3 from 8,000 m to the surface while the bottom sediments ranged from 0.67 to 6.65 g/m^2 (Kriss and Biriuzova, 1955). The above studies on the bacterial biomass of the various seas and oceans by Kriss and associates were summarized by Kriss (1956b).

Lakes and reservoirs have been the subject of a number of studies on productivity which have varied greatly in scope. Kuznetsov (1951) compared the distribution and biomass of bacteria and phytoplankton in the surface layers of Lake Baikal. The bacterial biomass ranged from 0.1 to 0.5 mg/l, which was 10 to 20% of the phytoplankton biomass. In a subsequent study Kuznetsov (1954) investigated the relationships between the original production of organic matter and the bacterial biomass in lakes. Data from other authors were used to illustrate that phytoplankton is the primary source of organic matter and that bacteria are concentrated in it. The

bacterial biomass in the sediments of oligotrophic lakes was 50 g/m² compared to values as high as 1.5 kg/m² in an eutrophic lake (Lake Beloe of Kosino), where its value was considered to be many times greater than the microbenthic biomass of the same layer. Gambarian (1954) estimated the biomass in the bay of Lake Sevan during a low water (three meters) period. He found the biomass to be 0.90 mg/l in five water samples, and 0.49 mg/g in five sediment samples. Romanova (1958) used submerged slides for the superficial characterization of the development of bacteria in the littoral zone of Lake Baikal. Despite their voluminous work on this subject, no mention was made of the work or techniques of Kriss and his colleagues.

The productivity of the Rybinsk Reservoir has been studied by Novozhilova of the "Borok" Institute of Reservoir Biology. The average bacterial biomass of 0.084 mg/l and generation time of 6.8 to 25.9 hours were used to estimate that zooplankton destroy from 649 to 2294 million bacteria per liter per day (Novozhilova, 1955a). In a similar paper Novozhilova (1957) stated that Vinberg and Yarovitsina "showed that only 13% of the total number of bacteria contained in the water settled on glass slides, consequently the method proposed by Kriss (Kriss and Rukina, 1952a) cannot characterize the intensity of the multiplication of the main mass of aquatic bacteria." For this reason Novozhilova used the method of Ivanov (1955) to estimate the daily production of bacterial biomass. An interesting observation was made that the rate of bacterial multiplication was reduced during the bloom of blue-green algae.

NUTRITION OF AQUATIC ANIMALS

The productivity and biomass data mean little economically unless they can be applied to commercially important food material. The role of bacteria in the nutrition of protozoa (Luck, Sheets, and Thomas, 1931), insect larvae (Barber, 1927), and invertebrates (ZoBell and Feltham, 1938) has been known for some time. The potential use of aquatic bacteria as a food resource was considered by Rodina (1949) in her review article on the subject. She pointed out that in addition to their other functions, the bacterial cells produced by chemosynthesis, photosynthesis, nitrogen fixation, and the conversion of soluble organic substances can play a role in the nutrition of many animal phyla.

A number of laboratory and field experiments have been conducted to verify and extend the above observations. Kalinenko (1951, 1952) of the Institute of Oceanography has studied the association of bacteria with marine invertebrates such as sea cucumbers, sea urchins, sea anemones, worms, corals, and sponges. The number of bacteria at the anal end of sea urchins was up to six times greater than at the oral end, and reflected both the qualitative and quantitative character of the bottom sediment. The marked bacterial population of the sea water within sponges, compared with the sparse content of the water surrounding them, was assumed to indicate a symbiotic relationship. Kalinenko believed that it was possible that marine invertebrates could not feed themselves solely on the organic detritus in the water that filters through them. The associated bacterial flora which he referred to as "internal bacterial nurseries" was considered to serve as a constant food reserve regardless of seasonal fluctuations of plants and animals.

Bacterial counts of material from the intestinal tract of the polychaete worm, *Nereis succinea*, obtained by Zhukova (1954) showed a ten-fold decrease from the anterior segment to the midgut and a subsequent slight increase in the posterior segment. Zhukova concluded that this decrease was due to digestion and that bacteria in bottom sediments are a link in the food chain. Zhukova's study may have prompted Kriss and Novozhilova (1954) to include data on yeast-feeding trials with *N. succinea* in their paper on the growth and vertical distribution of oceanic yeasts.

The effect of the number of bacteria on the development and variability of the Cladocera complex has been a subject of study by Manuilova of the Institute of Reservoir Biology. Increases in bacterial biomass correlated with an overall increase in body measurements and especially with an increase in the ratio of the head or carapace to body length (Manuilova, 1955). In her field and laboratory study on the water fleas in the Shumorovke River, Manuilova (1958) found that fluctuations in the bacterial blooms had a marked correlation with the zooplankton biomass and the survival and fertility of these organisms. Aquarium experiments in-

dicated that the different filtering activity of individual species made their survival and development dependent upon both the total number and generation time of the bacteria.

The use of microorganisms as a source of nutrients for fish has been investigated at the Institute of Microbiology and VNIRO. Kriss and Assman (1955) conducted some preliminary experiments to determine if a two-membered food chain, microorganisms directly to fish without invertebrate intermediates, was possible. On free choice, yeasts as well as invertebrates were ingested by sturgeon larvae. When weight change and mortality data on four species of larval aquarium fish fed four species of yeasts and *Azotobacter chroococcum* were compared with starved controls, the nutrient value of the yeasts and bacteria was found in all but one combination to be inferior to invertebrate food. Assman (1957) studied the use of microorganisms as a vitamin supplement for bone and barley meals. Organisms used were *Rhodotorula rubra* (vitamin A), *Saccharomyces carlsbergensis* (vitamin B_1), *S. cerevisiae* (vitamin D), *Aspergillus flavus* (vitamin B_2), and *Actinomyces olivaceus* (vitamin B_{12}). Comparisons with unsupplemented and vitamin supplemented rations indicated that under certain conditions the microbial vitamin-supplement allowed the maximum growth of aquarium fish, trout, and salmon fingerlings.

A number of studies have been concerned with the bacteriology of fish ponds and fishing kolkhozs in regard to the decomposition and cycling of fertilizers and the nutrition of animals. Representative studies on the fishing kolkhozs in the Volga delta such as "Iamat" are those by Ivanov (1954) on bacterial generation time, Egorova (1954) on the use of aquatic plants as green fertilizer, and Alipova (1955) on the role of *Azotobacter* in the nutrition of the zooplankton. This subject has been widely studied in regard to biomass (Rodina, 1952), nitrogen fixation (Rodina, 1954a), and hydrogen sulfide formation (Rodina and Romanova, 1954). In her review of this field Rodina (1954b) stressed the need for additional techniques and information on the use of bacteria to indicate the effect of inorganic and organic fertilizers upon the productivity of fish breeding ponds.

BACTERIAL PROCESSES

Bacterial processes in water bodies are as numerous and varied as the available substrates. Bacterial processes may be divided roughly into heterotrophic processes, those that decompose organic substances and cause their mineralization; and autotrophic processes, those that utilize inorganic substances for energy or substrate for cell synthesis. Since facultative autotrophs may metabolize heterotrophically and most heterotrophs can utilize certain inorganic substances, this separation is not absolute. Bacterial processes in aquatic habitats are discussed below in order to illustrate the extent and nature of the Soviet investigations.

Heterotrophic Processes

A. Organic matter decomposition. Many of the studies by Kuznetsov have concerned the role of bacteria in the cycling of organic substances in lakes. Kuznetsov (1949) used the isolated sample method to study the vertical distribution of organic matter and dissolved oxygen in the White Sea and various lakes. In eutrophic lakes 10 to 15% of the dissolved organic matter was utilized by bacteria, while in dystrophic and oligotrophic lakes this amounted to only 2 to 3 %. In eutrophic lakes the presence of organic decomposition in the deep water areas was indicated by a high nitrifying capacity of the water. One of the few papers correlating bacteriological data with those in collateral fields was that by Kuznetsov (1950). Some 14 lakes of varying degrees of salinity in the Kokcheeauskaia and Kurganskaia regions were studied with regard to *p*H, ionic strength, chloride ions, sulfate ions, type and quantity of phytoplankton bloom, total bacterial numbers, biomass, plate counts for saprophytic and sporeforming bacteria, and nitrification. The salt lakes in the steppe region had fewer bacteria (4×10^5 compared to 1×10^7/l) and a smaller biomass (0.3 compared to 7.5 mg/l) than the slightly saline lakes in the Makushino region. Kuznetsov stated that the capacity for nitrification indicated the intensity of mineralization while the nature of organic decomposition was indicated by the ratio of total saprophytes to sporeformers. Kuznetsov (1954) studied the relation of the primary production of organic substances to bacterial biomass. Half of the tables and figures presented, which were by other authors and had been previously published, showed the respiration, photosynthesis, and excretion of organic matter by phytoplankton and the association of bacteria with plankton. Kuznetsov found that

the daily death of about 5% of the phytoplankton caused a gradual addition of organic matter to the water which was reflected in the periodic increase in the bacterial population and decreased the ratio of phytoplankton biomass to bacterial biomass. The bacterial biomass of both the water and the bottom sediments was dependent upon both the nature of the water body as well as the time of year. Isolated samples demonstrated a three to four times greater bacterial activity and a shorter generation time in the 8 to 32 m layer than in the 6 to 8 m water layer of Lake Glubokoe. In eutrophic lakes such as Lake Beloe the value of the bacterial biomass (166 g/m^2) was much greater than the zoobenthic biomass (4.6 g/m^2) for the same 0.15 m layer of the bottom sediment. Guseva (1951) briefly reviewed the reciprocal relations between phytoplankton and saprophytic bacteria in water reservoirs. A monograph on "The role of microorganisms in the cycle of substances in lakes" has been written by Kuznetsov (1952).

The shallow stagnant salt water reservoirs of the Taman Peninsula were studied by Messineva (1948) to investigate the microbiological processes that result in the formation of bituminous deposits. The number of microorganisms involved in the decomposition of protein, cellulose, and neutral fats as well as in denitrification and sulfate reduction was estimated. Aquatic bacteriologists concerned with biogeochemistry have often focused their attention on oil deposits. Petroleum microbiology, which has many processes in common with aquatic microbiology, will not be discussed here. The reader is referred to the text by Beerstecher (1954) in which the active Soviet work in this field is covered. More recent reviews on the microflora of oil deposits (Kuznetsov, 1957) and the assimilation of hydrocarbons by microorganisms (Shturm, 1958) are in English translation.

B. Hydrogen sulfide formation. The heterotrophic process most studied by the Soviet aquatic bacteriologists has been the formation of hydrogen sulfide, especially in the Black Sea. The early bacteriological studies on hydrogen sulfide formation in the Black Sea conducted by Russian scientists in the late nineteenth century were reviewed by Shturm (1951). The role of bacteria in decomposing organic material and in forming carbonate rocks and hydrogen sulfide in the Black Sea and under laboratory conditions was studied by Strakhov (1948). Kriss and Rukina (1949b) studied the origin of hydrogen sulfide in the Black Sea. Sulfate-reducing microorganisms were infrequently found in the water mass and then mainly in the hydrogen sulfide zone and in large water aliquots (25 ml). Hydrogen sulfide production, as a result of both sulfate reduction and the decomposition of organic matter, was very active in the bacteria-rich bottom sediments. It was impossible to determine which process exceeded the other. Kriss (1949) and Kriss and Rukina (1949c) studied the role of microorganisms in the accumulation of hydrogen sulfide, ammonia, and methane in the depths of the Black Sea. The existing conditions in the oxygen zone, hydrogen sulfide zone, and the bottom sediments were believed to dictate the biochemical processes of different physiological groups in these different areas of the sea. An oxidation-reduction equilibrium was believed to result from the opposing microbiological processes which caused the accumulation of reduced products (ammonia, hydrogen sulfide, and methane) and the oxidation of these substrates as well as decomposing organic matter. Since both oxidizing and reducing processes were present, the authors felt that the term "hydrogen sulfide zone" was more descriptive than the older term, "reducing zone." The sulfate-reducing activity of water samples from the Black Sea was determined by the ability of enrichment cultures to produce hydrogen sulfide (Osnitskaia, 1949). Contrary to the observations of Kriss, activity was obtained more frequently in water samples from the oxygen zone than from the hydrogen sulfide zone. Sediment samples were more active than water samples. The vertical distribution of morphologically characteristic filamentous forms of purple sulfur bacteria, which were more frequently observed in the deeper levels of the hydrogen sulfide zone of the Black Sea, was described by Kriss and Rukina (1953).

The rate of bacterial sulfate reduction has been studied by use of isotopes. Ivanov (1956) used S^{35}-labeled sulfate to study this process in isolated samples of water and sediment from Lake Belovod. Five water samples (70–100 ml) did not exhibit detectable activity. Sulfate reduction was greater in three sediment samples from the deep water area (0.12 mg $H_2S/l/day$) than in one littoral sample (0.067 mg H_2S/day). A detailed description of the S^{35} method used to determine the sulfate-reducing capacities of

reservoir mud was given by Sokolova and Sorokin (1957). Vigorous activity was observed (up to 0.28 mg H_2S/l/day) in the Rybinsk Reservoir despite the relatively low concentration of sulfates. Since readily assimilable carbohydrates increased the activity, the authors concluded that this may be the limiting factor in the old reservoir, Lake Beloe, where sulfate reduction was negligible despite adequate concentrations of sulfate. A similar study was conducted on ten bottom sediments from a new reservoir (the Gor'kovskoe) by Sokolova and Sorokin (1958). Bacterial counts of sulfate-reducing bacteria in samples that contained relatively low amounts of hydrogen sulfide did not correlate with their active sulfate-reducing activity.

C. Miscellaneous studies. In addition to the studies on phytoplankton decomposition and production of hydrogen sulfide, a number of miscellaneous processes have been investigated. In an attempt to detect bacteriophage in the Black Sea (Kriss and Rukina, 1947), pooled samples from various depths were tested by the direct, enrichment, and passage methods against bacterial isolates from the same samples. Phages from all depths had slight but detectable activity against cocci, sporeforming, and nonsporeforming rods. However, some of the test organisms were found to be lysogenic and specificity of the phages was not determined. In order to investigate the occurrence of chitin-digesting organisms in the Black Sea, Kopp and Markianovich (1950) used water samples from various depths to inoculate a crab shell medium. Digestion was measured by the incubation time necessary to detect ammonia and to produce softening of the shell. Activity was verified by subcultures on chemically pure chitin. No quantitative or p[illegible]ure studies were made on the 16 positive samples.

Water and sediment samples from the Black Sea were used by Osnitskaia (1952) in an attempt to detect the presence of organisms which could reduce phosphates to phosphoric and phosphorous acids, and to oxidize phosphites to phosphates. Organisms capable of these reactions were not detected. In a paper on bacterial fouling (Kalinenko and Mefedova, 1956), glass slides coated with anticorrosive and antifouling paints were submerged in sea water. None of the preparations inhibited the rapid development of a microbial film encrusted with calcium, iron, and magnesium salts which then permitted the attachment of marine invertebrates.

In order to study the development of bacteria on steel surfaces, Nikitina and Ulanovskii (1954) determined the number of proteolytic (aerobic and anaerobic), denitrifying, nitrifying, and sulfate-reducing bacteria. In the corrosion products there was an inverse relationship between the development of proteolytic (surface) and sulfate-reducing (subsurface) bacteria. In a subsequent paper Ulanovskii and Nikitina (1956) used two unidentified marine bacteria to study their effect on corrosion intensification. The intensification of corrosion by bacteria was attributed to microzonal decreases in *p*H and oxygen content which were believed to set up microgalvanic cells. Rosenberg, Ulanovskii, and Korovin (1959) conducted a similar study on the effect of bacteria on the corrosion of uncorroded steel in narrow spaces. The effect of pure cultures and galvanic cells on the corrosion of the test strips was determined in regard to *p*H and number of bacteria.

In a paper entitled "The basic tasks of sea and ocean microbiology," Kriss (1954c) discussed the importance of the discovery of barophilic microorganisms in the bottom sediments of the Philippine Trench (ZoBell, 1952) and its significance to bacterial processes in the ocean depths. This subject, which has been extensively studied by ZoBell and associates (ZoBell and Johnson, 1949; ZoBell and Oppenheimer, 1950; Oppenheimer and ZoBell, 1952), has apparently encouraged similar Soviet studies. Kriss (1955d) used procedures similar to those of ZoBell to demonstrate the presence of barotolerant organisms in the deep-water bottom sediments of the Okhotsk Sea and adjoining areas of the Pacific Ocean. An associate of Kriss, Chumac has been studying the physiology of barotolerant organisms (Chumac, 1959).

Autotrophic processes

Some of the more biochemically oriented Soviet investigations concern those of autotrophic processes in reservoirs. In a study on physiological ecology, Lialikova (1957) investigated the mass development of the purple sulfur bacterium, *Chromatium okenii*, at a depth of 14 m in Lake Belovod. Her objective was to determine if chemosynthetic or photosynthetic processes occurred under these natural conditions.

These processes were followed by C^{14}-labelled carbonate which was added to isolated water samples in light and dark bottles. Bacterial photosynthesis occurred at greater depths than algal photosynthesis by *Scenedesmus quadricauda*. Photosynthesis fixed 0.88 mg of carbon dioxide per liter of lake water compared to 0.26 mg by chemosynthesis. Although the light was not optimum for photosynthesis at 14 m, the concentration of hydrogen sulfide required by this organism occurred at this depth. Another photosynthetic purple sulfur bacterium, *Chromatium vinosum*, which was isolated from Lake Beloe mud, was studied with regard to optimum conditions for growth, photosynthetic capacity, and ability to utilize organic compounds (Osnitskaia, 1958). The results confirmed those by previous investigators.

Sorokin of the Institute of Reservoir Biology and the N. A. Morozov Biological Station of the "Borok" Academy of Sciences has conducted a number of radio-isotope studies in order to investigate the rate of chemosynthetic processes in lakes and reservoirs. C^{14}-labelled carbonates were used to determine the extent of these processes in the different silt deposits of the Rybinsk Reservoir (Sorokin, 1955a). In the sulfur-containing silts with an abundant microflora, four to six milligrams of organic substance per kilogram of sediment were produced daily. This process was enhanced tenfold by the addition of hydrogen and one- to two-fold by the addition of methane. The addition of sodium azide which inhibited heterotrophic assimilation of carbon dioxide indicated that this process was 15% as much as that due to chemosynthesis. In a similar study on fresh muds from fish ponds (Sorokin, 1955b), the daily chemosynthesis was three to nine milligrams of organic carbon per kilogram of dried mud. Sodium azide inhibition again indicated that heterotrophic carbon dioxide fixation accounted for 10 to 20% of the total carbon fixed.

In a series of papers Sorokin has further perfected the isotope techniques for studying chemosynthesis in water and sediment samples and has investigated the amounts of substrate required for the production of each unit of bacterial cells. The amount of oxygen utilized for the oxidation of methane and hydrogen by autotrophic bacteria, and the accompanying synthesis of organic carbon in reservoir water was determined by Sorokin (1957a). Data from three experiments indicated that the oxidation of 2 to 4 mg of hydrogen or 20 to 30 mg of methane was required for the synthesis of 1 mg of organic carbon. Sorokin (1957b) studied the extent of winter chemosynthesis in the water layers of the Rybinsk Reservoir. Observations on the vertical distribution of bacterial chemosynthesis, total bacterial numbers, oxygen, ammonia, nitrate, and plankton biomass indicated that chemosynthesis, which occurred in the area of plankton development and increased toward the bottom, was apparently limited right on the bottom by a lack of oxygen. Hydrogen and methane served as the main energy sources for chemosynthesis. A less extensive study was conducted to determine the rates of chemosynthesis in the summer (Sorokin, 1958b). Maximum chemosynthesis (0.015 to 0.3 mg of carbon/l/day) was correlated with the maximum autotrophic activity (methane and hydrogen oxidation) in the bottom layer of water. A detailed description of the C^{14} method for the determination of the rate of chemosynthesis in reservoir sediments as a result of the oxidation of methane and hydrogen was given by Sorokin (1958a). In this study the influence of temperature and easily assimilated organic substances under varying degrees of aeration was determined. Throughout this series of papers the possible value of this bacterial synthesis for the nutrition of the benthic zoopopulation was stressed. Sorokin (1959) has fed cells produced by methane- and hydrogen-oxidizing bacteria to aquatic invertebrates.

ECOLOGY

A number of Soviet investigators have studied the influence of physical, chemical, and other biological factors on bacteria in the aquatic habitat. Nikitina (1955a, 1955b) at the Murmansk Biological Station correlated the bacterial flora of the East Murman shore of the Barents Sea with seasonal changes in temperature and the animal and plant populations. Direct counts and titers of sulfate-reducing, nitrifying, denitrifying, and putrefactive bacteria indicated that both these factors influenced the marked fluctuations of the different physiological groups throughout the year. Sulfate-reducing bacteria had a maximum development in May during a vigorous development of aquatic plants (water,

1°; air, 2° C), while the remaining groups had their maximum development in July which coincided with the temperature maximum (water, 7.6°; air, 11.4° C). When the temperature decreased in October the growth and reproduction of denitrifying and nitrifying bacteria ceased while the less temperature-sensitive sulfate-reducing and putrefactive bacteria had a second maximum in November and December (water, 2° to 4°; air, −7° to −19° C). This was due presumably to the mass death of plants and animals and the accumulation of their organic matter. Although bacteriological processes were most active in the surface layers, identical seasonal changes in the microorganisms of the deep sediment layers indicated that these organisms also participated in mineralization. Bacteriological processes in the sediments of the East Murman littoral area were also studied by Ruban (1955). The number of sulfate-reducing and putrefactive bacteria as well as analyses for organic and inorganic carbon and total nitrogen were determined on the littoral sediments in areas where the fauna, flora, and sediment types varied. Sulfate-reducing bacteria which were associated with brown algae or their remains inhibited the mineralization of organic matter by the putrefactive bacteria which were associated with the mollusc populations. These interacting processes as well as most of the organic carbon occurred in the upper 20 to 25 cm layer of the littoral sediments.

The interrelationships between bacteria, chemical activity, and the animal population in the sediments of the northwestern part of the Pacific Ocean were studied by Rozenberg and Mefedova (1956). Determinations of microbenthic biomass, plate and direct bacterial counts, ammonia, phosphate, nitrate, and alkalinity indicated that sediments rich in zoobenthos contained more bacteria and a higher concentration of biogenic elements than sediments poor in benthic organisms. In an identical study over a larger area of the Pacific Ocean, Rozenberg and Mefedova (1958) observed that the sediments of the tropic zone were poorer than those of the northern zone in zoo-organisms and biogenic elements, while the bacterial population was the same. There was a decrease in all components with water depth and distance from shore, while the number of bacteria increased with an increase in the zoopopulation. As the viable bacterial count decreased vertically in the sediment cores, the concentration of ammonia nitrogen increased.

Similar ecological studies have been conducted on lakes. In an investigation of the microflora of the petrous littoral portion of Lake Baikal, Rodina (1954c) examined rocks, sandy areas, water samples, and examples of the fauna and flora. Organisms enumerated were yeasts, nitrifiers, nitrogen fixers, denitrifiers, sporeformers, and total bacteria. Biomass estimations and chemical determinations were also made. The rich petrous microflora, which was associated with the growth of plants and animals, consisted of complex aggregates of single species microcolonies. The diverse microflora included putrefactive organisms as well as those that favor nitrogen fixation and nitrification. The number of bacteria in the sandy areas was less than on the rocks and decreased with an increase in grain size, which correlated with a decrease in organic content. The small bacterial content of water in the littoral area was affected by storm conditions while the bacterial population of the open and deep regions decreased with depth. The high incidence of nitrogen-fixing microorganisms of the genus *Azotobacter* on the attached algae was regarded as an indication of a symbiotic relationship. Laboratory experiments and field observations indicated that the rich microflora of the petrous littoral environment played an important role in the nutrition of indigenous molluscs and sponges. Zavarzina (1955) studied the distribution and inhibition of bacteria in the bottom sediments of Lake Biserova. Except for a weak inhibitory substance for *Sarcina lutea*, antibiotic substances were not detected. The absence of spontaneous fermentation in the 400 cm layer indicated that the smaller number of viable organisms in this layer was due primarily to an absence of readily assimilable organic substances. Ecological studies on autotrophic organisms have been previously mentioned (Lialikova, 1957; Sorokin, 1957b) in the section on autotrophic processes.

TAXONOMIC IDENTIFICATION AND MORPHOLOGICAL DESCRIPTION

A usual result of analytical bacteriological studies is the isolation and collection of cultures which are described to some extent. The inadequacy of artificial keys and the inherent variation within bacterial species are only two of the many problems in bacterial taxonomy. After

describing an organism on the basis of accepted procedures, one is faced with three alternatives: (1) "force the organism to fit" by relating it to the species that it most closely resembles, (2) "shake out the easy ones" and let the difficult ones go with a description only, or (3) "tack on a handle" by creating a new species or by using a new combination. Apparently the Soviet aquatic bacteriologists, like the Americans, have been forced into all three alternatives.

Taxonomy

A few studies have been conducted on the species composition of the heterotrophic microorganisms obtained during the various expeditions. During the 1946 Black Sea Expedition (Kriss and Rukina, 1949a) some 300 isolates were obtained which were described in detail by Kriss, Rukina, and Biriuzova (1949). In a subsequent study of the some 1,700 cultures obtained during the 1946, 1948, and 1949 expeditions, 733 of these were described in an extensive work by Kriss, Markianovich, and Rukina (1954). In classifying these organisms according to the manual by the noted Russian taxonomist, N. A. Krassil'nikov (1949), the authors state: "This is done with reservation since microorganisms are difficult to classify into particular species. But we refrain, contrary to some other groups of investigators, from describing the marine organisms as new species and consider them varieties of one and the same species to which they closely resemble." A total of 154 strains consisting of 60 species (16 new combinations) were individually described according to the standard criteria of morphology and biochemical characteristics. These organisms were classified as belonging to the following genera: *Micrococcus* (8 species), *Sarcina* (5 species), *Pseudobacterium* (13 species), *Bacterium* (5 species), *Pseudomonas* (1 species), *Chromobacterium* (6 species), *Mycobacterium* (4 species), *Bacillus* (18 species), and *Actinomyces* (3 species). The vertical distribution of the various species and strains was illustrated by 15 figures. Fifty cultures obtained during the 1946 Black Sea Expedition were described by Kopp (1949). Markianovich (1954) classified these organisms and found 13 of the 26 species were different from those identified by Kriss, Markianovich, and Rukina (1954).

During the cruise of the *Vitiaz* in the northwestern part of the Pacific Ocean in 1953, Mefedova (1955) isolated 25 morphologically different cultures from bottom sediments. These cultures were studied by the methods used by ZoBell and Upham (1944) and were classified according to ZoBell and Upham and Bergey's manual (Breed, Murray, and Hitchens, 1948). The 9 cultures were identified as different species of the genera *Bacillus* (two species), *Bacterium* (three species), *Micrococcus* (two species), and *Flavobacterium* (one species). The remaining 16 cultures were described but were not identified.

In order to characterize the saprophytic microflora of lakes of varying degrees of trophicity, Egorova, Deriugina, and Kuznetsov (1952) studied bacterial isolates from 30 lakes. One hundred and nineteen species were identified according to Krassil'nikov (1949). The authors discussed the new principles of classification used in Krassil'nikov's manual and how they differed from Bergey's manual. The inclusion of the coccal forms, *Micrococcus* and *Sarcina*, in the order *Actinomycetales* instead of *Eubacteriales* explains the authors' startling conclusion that half the species obtained belonged to this order. The species distribution by lakes was presented. There was a gradual transition from the fresh water lakes (diverse flora and low numbers) to the alkali-salt lakes (simple flora and large population.

The yeasts have been the subject of a number of investigations by Novozhilova, formerly at the Institute of Microbiology and more recently at the Institute of Reservoir Biology. During a study on the distribution of yeasts in the Black Sea (Kriss, Rukina, and Tiknonenko, 1952), 40 cultures of asporogenous yeasts were obtained. These were studied by the usual morphological, cultural, and physiological methods (Rukina and Novozhilova, 1952). The species were identified according to the manual by Lodder (1934) and when "... it proved impossible by any sign to classify the given form as a member of a definite species, such a form was then considered a variant of the species to which it most closely approached." The cultures were classified as *Rhodotorula* (four species), *Torulopsis* (five species), and *Hanseniaspora* (one species), as well as several unidentified species of the subfamily Mycotoruloideae.

A comprehensive study on oceanic yeasts was conducted by Novozhilova (1955b) on 525 cultures isolated from various depths of the Black and Okhotsk Seas and the Pacific Ocean. These yeasts were also classified according to Lodder

and were identified as eight species of *Torulopsis* (34 strains), six species of *Rhodotorula* (42 strains), and two species of *Sporobolomyces* (8 strains). Each strain was individually described. The wide distribution of various strains in the different seas and horizons was illustrated by figures.

Similar methods were used by Rozanova and Novozhilova (1958) to characterize the distribution and species composition of the yeasts in the Rybinsk Reservoir. The 67 strains studied were related to three species of *Torulopsis* and five species of *Rhodotorula*. The distribution of yeasts and yeast-like fungi in lakes was investigated by Rodina (1950) but the cultures were not identified.

The purpose of the above work on identification has mainly been to "tag" the organism in order to determine its distribution in the various seas and their horizons. Work of a more taxonomic nature has mainly been on the smaller inland water bodies and usually in connection with a certain process or problem. Halophilic strains of specialized organisms are such an example. Zaslavskii (1952) of the Odessa Institute of Food Technology studied the sulfur-oxidizing bacteria of the Kuialnitskii Liman. When the water level was low and the salt concentration was high, the organisms present were found to be obligate halophiles which required a minimum of 6% sodium chloride. These heterotrophic organisms, that were previously described by Isachenko and Salimonskii, were studied only in regard to salt tolerance and nitrogen sources and were named *Thiobacterium issatschenkoi*. Tepliakova (1952) of the Institute of Soil Sciences isolated two cellulolytic vibrios from saline marsh and sediment. These were more active than non-halophiles. A sketchy description was given for an obligate halophile that assimilated cellulose and to a lesser extent glucose (*Cellvibrio winogradskii*, n. sp.) and a facultative halophile which could use a number of organic acids and carbohydrates as a carbon source (*Cellvibrio halophilus*, n. sp.). Kurochkin (1958) isolated a sporeforming organism from Lake Tinak mud that formed red-pigmented colonies on media containing ferric chloride and produced mucoid droplets at the periphery of the colony. This organism, that was named *Bacillus tinakiensis*, was described with regard to its morphological, cultural, and antagonistic properties. It was found to be irregularly distributed in low numbers in the mud of certain lakes.

New species of organisms from reservoirs have been described on the basis of morphology only. Razumov (1949) described an organism with iron oxide inclusions which formed spoke-like colonies and produced planktonic blooms which he named *Gallionella kljasmiensis* (n. sp.). This organism was classified as *Gallionella planktonica* by Krassil'nikov (1949), while Sokolova (1959) believed that it had no relation to the genus *Gallionella* and placed it in the genus *Blastocaulis*. Confusion arising out of the classification of iron bacteria on a morphological basis was further illustrated by Sokolova (1959). She conducted a morphological study on the iron bacteria of Lake Glubokoe and discussed the conflicting nomenclature of the 13 species observed. Rodina (1956) of the Institute of Zoology obtained cultures of a nitrogen-fixing spirillum which produced involution forms on organic media. The author disagreed with Krassil'nikov's designation of this organism as a variety of *Spirillum lipoferum* Beijerinck and named her isolates *Spirillum azotocolligens*.

Other studies, such as those by Fedorov's students at the M. V. Lomonosov Moscow State University, have been concerned with basic studies on photosynthetic and autotrophic bacteria. These papers on the taxonomy of the photosynthetic green sulfur bacteria (Kondrat'eva, Fedorov, and Greshnykh, 1958; Shaposhnikov, Kondrat'eva, and Fedorov, 1958) have confirmed the characteristics and species names described by American workers in this field.

Morphology

The numerous studies on distribution, biomass, and rate of multiplication have relied heavily or solely upon direct microscopic methods. In these papers where description was attempted it was based, by necessity, on morphology. At least ten papers by Kriss and colleagues contain drawings showing the vertical distribution of the various morphological types. These include studies on the Arctic Ocean (Kriss, 1955a, 1955b, 1958; Kriss and Lambina, 1955; Kriss, Biriuzova, Tikhonenko, and Lambina, 1955), Black Sea (Kriss and Lebedeva, 1953; Kriss, Rukina, and Tikhonenko, 1950), Okhotsk Sea (Kriss and Rukina, 1952a), Caspian Sea (Kriss, Biriuzova and Rukina, 1954), and the

Pacific Ocean (Kriss and Biriuzova, 1955). Materials used for these morphological studies were erythrosine-stained membrane filter preparations and submerged slides. As previously mentioned, only certain organisms have the ability to settle on and adhere to glass. However, Kriss has remarked on several occasions that some forms are apparently obligate peripheral organisms, since they are found only on submerged slides.

These morphological studies have been summarized by Kriss, Biriuzova, and Lebedeva (1958). Although many of the morphological forms were common to all water bodies studied, some types were sea- or -ocean specific. These authors emphasized the point that many of these forms could not be cultivated either on laboratory media or isolated water samples. In addition to 7 unusual and yeast shaped forms, 21 rod-shaped, 7 filamentous, and 5 coccal forms were described and listed according to the depth of the body of water from which they were obtained.

One of the interesting results of these morphological observations was the description of organisms that were believed to be intermediate between bacteria and protozoa. They were put in a new class, *Krassilnikoviae*, named in honor of N. A. Krassil'nikov (Kriss and Mitzkevich, 1957). This distinct morphological form developed on submerged slides in the Black Sea and the Arctic and Pacific Oceans. It was not seen (in its complete form) on membrane ultrafilters, in sea water, or on laboratory media. The body of this organism was a non-branching, non-septate filament with a head at one end which consisted of a cluster of round bodies. The vertical distribution of the filamentous part and the thick-walled round bodies was presented. In this connection it is interesting to note that this same paper was subsequently republished in an English language journal (Kriss and Mitzkevich, 1959) complete in almost every respect except the citation of the previous publication. This material was again described in great detail in the text by Kriss (1959a).

Direct microscopic techniques have been applied to other problems by Kriss. A paper entitled "Fate of dead organic substances in the Black Sea" (Kriss, Rukina, and Biriuzova, 1951a) used direct microscopic means to classify the horizontal and vertical distribution of this material in the oxygen and hydrogen sulfide zones and to note the state of decomposition. Another paper (Kriss, Tikhonenko, and Biriuzova, 1958) contains electron micrographs of aseptically collected water samples from vertical profiles in the Black Sea and the Kuril-Kamchatka Trough in the Pacific Ocean. The authors observed rounded particles in considerable concentration from most depths. Six forms varying from 0.5 to 1,000 mμ were described in detail. Although it was not known whether these particles were aggregates of dissolved organic matter or saprophytic viruses, the authors were certain that they were not examples of the primary creation of life, since Oparin (1957) had stated that life could not have originated in the marine basins.

GENERAL DISCUSSION

During the preparation of this article the Academy of Sciences of the USSR published a text by Kriss (1959a) entitled *Marine Microbiology (Deep-sea)*. This contribution to the field is mainly a collection of the data obtained and the philosophies developed during the first 12 years of the Institute of Microbiology's organized investigations of the different seas and oceans. The original figures and tables from the papers by Kriss and associates have been supplemented to a limited extent by reproduced data from other Soviet workers, ZoBell's (1946) monograph, etc. This 455-page book contains nine chapters: deep-sea microbiological methods, quantitative distribution of heterotrophs, species composition, biochemical activities, total numbers and biomass, morphological characterization, rate of multiplication, microorganisms and the biological productivity of the sea, and microorganisms as indicators of hydrological phenomena. Kriss emphasizes the contributions made by Soviet workers on the deep-sea, especially by the use of direct microscopic methods. The 595 references cited contain 450 Russian articles and 145 non-Russian references of which 108 are in the English language. The majority of the Russian literature cited refers to collateral studies in physical and biological oceanography. In addition to an English translation that will be published in Scotland, it is understood that this text is being translated into German as was the monograph by Kuznetsov (1959) which was originally published in 1952 and is now out of print.

Virtually all the papers referred to, in the various abstracts, bibliographies, accessions, and

translation sources as well as the reference sections of the various papers and monographs, could be found in various Government and university libraries. On the basis of the available papers some tentative conclusions as to the accessibility of the Soviet literature may be made. Over 60% of the articles appeared in *Mikrobiologiya* (45%) and *Doklady Akademii Nauk SSSR* (19%) which are now available in translations sponsored by the National Science Foundation through the American Institute of Biological Sciences. The remaining 36% of the papers appeared in 17 other journals or monograph series. Papers published in the cryllic alphabet which appear in *Referativnyy Zhurnal—Biologiya* are now included in *Biological Abstracts*. In addition, translated articles are listed in *Technical Translations* published by the Department of Commerce. A general aid to the Soviet literature is the recent National Science Foundation pamphlet (Anon., 1959) on *Soviet Scientific Information*.

The energetic Soviet studies on aquatic bacteriology have concentrated on the quantitative characterization of the microbial population of the seas and oceans. The facilities for field studies have been used to advantage to obtain data on the distribution and biomass of the various morphological types. Few papers have been concerned with bacterial physiology and biochemistry. Observations on interesting phenomena such as algal antibiosis have not been followed up on a physiological basis. The recent emphasis on physiology and biochemistry in other disciplines may indicate that this area of aquatic bacteriology will receive greater attention in the future.

Despite the numerous contributions to aquatic bacteriology by investigators scattered the world over at various types of institutions, the number of investigators is pitifully small and the foundation of knowledge in this field is still being laid. Only by the liberal exchange of data and philosophical approaches across language barriers can new directions and advances occur under optimum conditions. It is the author's wish that this review will in some measure contribute to a better understanding of Soviet aquatic bacteriology.

ACKNOWLEDGMENTS

The author sincerely acknowledges: Miss Lucy Lee Lancaster, the Virginia Polytechnic Institute Assistant Librarian, for her cheerful assistance in checking the references and obtaining the source material; Dr. Esteban Boltovsky of the Museo Argentino de Ciencias Naturales, Buenos Aires, for his aid with *Refernativnyy Zhurnal*; Mrs. M. G. Hale for her invaluable assistance in translating the articles; my wife, Janice, for her untiring support and typing chores; and my colleagues and neighbors, Drs. B. W. Nelson and W. E. C. Moore for their comments and suggestions.

LIST OF LITERATURE

ALFIMOV, N. N. 1954. Comparative evaluation of methods for the determination of the quantity of bacteria in sea water. *Mikrobiologiia*, 23: 693–697.

ALIPOVA, M. G. 1955. The role of *Azotobacter* in relation to the nutrition of the zoopopulation in the fishing kolkhoz "Iamat." *Trudy Inst. Mikrobiol.*, no. 4, 207–212.

ANONYMOUS. 1959. *Providing U. S. Scientists with Soviet Scientific Information*. 36 pp. Rev. ed., Off. Sci. Inform. Serv., Nat. Sci. Found., May.

ASSMAN, A. V. 1957. Microorganisms as donors of vitamins for nutrition of baby fish. *Voprosy Ikhtiologii*, no. 9, 169–187.

BARBER, M. A. 1927. The food of anopheline larvae, food organisms in pure culture. *U. S. Public Health Reports*, Reprint 1161.

BEERSTECHER, E., JR. 1954. *Petroleum Microbiology*. 375 pp. Elsevier Press, Houston and New York.

BREED, R. S., E. G. D. MURRAY, and A. P. HITCHENS. 1948. *Bergey's Manual of Determinative Bacteriology*, 6th Ed. 1529 pp. Williams & Wilkins Co., Baltimore.

BURKHANOV, V. 1956. *New Soviet Discoveries in the Arctic*. 60 pp. Foreign Languages Publishing House, Moscow (in english).

CHOLODNY, N. 1930. Ueber eine neue Methode zur Untersuchung der Bodenmikroflora. *Arch. Mikrobiol.*, 1: 620–652.

CHUMAC, M. D. 1959. The effect of high pressure on the rate of glucose utilization by barotolerant bacteria. *Doklady Akad. Nauk SSSR*, 126: 1107–1109.

EGOROVA, A. A. 1954. Experiment on the use of aquatic plants as a green fertilizer in fish farms of the Volga delta (hydrochemical and microbiological investigations). *Trudy Inst. Mikrobiol.*, no. 3, 201–212.

——, Z. P. DERIUGINA, and S. I. KUZNETSOV. 1952.

Characteristics of the saprophytic microflora of the water of lakes of varying degrees of trophicity. *Trudy Inst. Mikrobiol.*, no. 2, 139–149 (SLA, RT-4259).

FISCHER, B. 1894. Die Bakterien des Meeres nach den Untersuchungen der Plankton-expedition unter gleichzeiter Berücksichtigung einiger älterer und neurer Untersuchuengen. *Zbl. Bakt.*, 15: 657–666.

GAMBARIAN, M. E. 1954. Distribution, quantity and biomass of bacteria in the bay of Lake Sevan. *Mikrobiologiia*, 23: 462–463.

GUSEVA, K. A. 1951. Reciprocal relations between phytoplankton and saprophytic bacteria in a water reservoir. *Trudy Problemykh i Tematicheskikh Soveshchanii Zool. Inst.*, no. 1, 34–38.

HENRICI, A. T. 1933. Studies on freshwater bacteria. I. A direct microscopic technique. *J. Bact.*, 25: 277–287.

——. 1936. Studies on freshwater bacteria. III. Quantitative aspects of the direct microscopic method. *J. Bact.*, 32: 265–280.

HUTNER, S. H., L. PROVASOLI, J. J. A. MCLAUGHLIN, and I. J. PINTNER. 1956. Biochemical-geography: Some aspects of recent vitamin research. *Geogr. Rev.*, 46: 404–407.

IERUSALIMSKY, N. D. 1954. Calculation of the rate of growth of water microorganisms on glass slides. *Mikrobiologiia*, 23: 561–570.

ISSACHENKO, B. L. 1914. *Investigations on the Bacteria of the Glacial Arctic Ocean.* 300 pp. Monograph, Petrograd.

——. 1951. Investigations of the bacteria of the Arctic Ocean (This work was originally published as Trudy Murmanskoi nauchnopromyslovoi ekspeditsii 1906 g., 1914. pp. 1–297). *Izbrannye Trudy*, no. 1, 111–285, 391–404.

IVANOV, M. V. 1954. Determining the time of the generation of water bacteria on the fish-farm in the Volga River delta. *Trudy Inst. Mikrobiol.*, no. 3, 213–220.

——. 1955. Method for the determination of bacterial biomass formation in reservoirs. *Mikrobiologiia*, 24: 79–89.

——. 1956. The use of isotopes for the study of the intensity of the process of reduction of sulfate in Lake Belovod. *Mikrobiologiia*, 25: 305–309 (ATS 29H13R).

JANNASCH, H. W., and G. E. JONES. 1959. Bacterial populations in sea water as determined by different methods of enumeration. *Limnol. Oceanogr.*, 4: 128–139.

KALINENKO, V. O. 1951. Bacteria and marine invertebrates. *Mikrobiologiia*, 20: 320–323.

——. 1952. Bacteria and invertebrates at the bottom of the sea. *Mikrobiologiia*, 21: 555–560.

——, and N. A. MEFEDOVA. 1956. Bacterial fouling of the submerged portion of a ship. *Mikrobiologiia*, 25: 191–194.

KARZINKIN, G. S. 1934. Zum Studium des bacterialen Periphytons. *Proc. Kossino Limnol. Sta.*, 17: 21–48.

KONDRAT'EVA, E. N., V. D. FEDOROV, and K. P. GRESHNYKH. 1958. Contribution to the study of the morphology of *Chlorobium thiosulfatophilum*. *Doklady Akad. Nauk SSSR*, 123: 365 (AIBS Trans. 948).

KOPP, F. I. 1949. Cultures isolated from materials of the 1946 expedition. *Trudy Sevastopol Biol. Stantsii*, 7: 28–49.

——, and E. M. MARKIANOVICH. 1950. About bacteria that digest chitin in the Black Sea. *Doklady Akad. Nauk SSSR*, 75: 859–862.

KRASSIL'NIKOV, N. A. 1949. *Guide to the Identification of Bacteria and Actinomycetes.* 829 pp. Akad. Nauk SSSR, Moscow.

KRISS, A. E. 1947. Microorganisms of soils and seas of the eastern part of the Soviet Arctic. *Vses. geograf. s-ezd, Trudy*, 2: 359–367.

——. 1949. The role of microorganisms in the accumulation of hydrogen sulfide, ammonia and nitrogen in the depths of the Black Sea. *Priroda*, 38: 35–46.

——. 1954a. Role of microorganisms in the biological productivity of the Black Sea. *Uspekhi Sovremennoi Biol.*, 38: 86–110 (SLA, RT-3075).

——. 1954b. Microorganisms and the Biological Productivity of Bodies of Water. Moscow, Series III, no. 32, pp. 3–24 (SLA, RT-2782).

——. 1954c. The basic tasks of sea and ocean microbiology. *Vestnik Akad. Nauk SSSR*, no. 8, 22–34 (SLA, RT-2376).

——. 1955a. Microbiological investigations in the region of the North Pole. *Vestnik Akad. Nauk SSSR*, no. 1, 30–40.

——. 1955b. Bacterial world of the ocean in the region of the North Pole. *Priroda*, 44: 61–68 (SLA, R-4815).

——. 1955c. New microbiological investigations in the central Arctic. *Vestnik Akad. Nauk SSSR*, no. 9, 31–34.

——. 1955d. Bacterial population of the deep-sea regions of the Okhotsk Sea and the Pacific Ocean. *Priroda*, 44: 65–72 (SLA, R-4812).

——. 1956a. Microbiology of the Caspian Sea. *Uspekhi Sovremennoi Biol.*, 42: 175–201.

——. 1956b. The density of microbial population and biomass at different depths of seas and oceans. *Doklady Akad. Nauk SSSR*, 111: 1356–1358.

——. 1957. Microbiological investigations in the central Arctic in 1956. *Doklady Akad. Nauk SSSR*, 114: 199–202 (AIBS Trans. 573–576).

——. 1958. Microbe population in the region of

the North Pole. *Trudy Inst. Mikrobiol.*, no. 5, 186–198.

KRISS, A. E. 1959a. *Marine Microbiology (Deep-sea)*. 455 pp. Izd. Akad. Nauk SSSR, Moscow.

——. 1959b. Distribution of water masses in the Indian Ocean and in the central Pacific Ocean according to microbiological data. *Internat. Oceanogr. Congress, Preprints*. Amer. Assoc. Adv. Sci., Wash., pp. 555–560.

——, and A. V. ASSMAN. 1955. Microorganisms as fish food. *Doklady Akad. Nauk SSSR*, 105: 606–609 (NRC, C2275).

——, and V. I. BIRIUZOVA. 1955. Vertical distribution of microorganisms in the Kuril-Kamchatka depression of the Pacific Ocean. *Doklady Akad. Nauk SSSR*, 100: 1175–1178 (SLA, R-4814).

——, ——, and M. N. LEBEDEVA. 1958. Morphological characterization of the microbe population in seas and oceans. *Doklady Akad. Nauk SSSR*, 123: 845–848.

——, ——, and E. A. RUKINA. 1954. Distribution of microorganisms through the water horizons of the central and southern parts of the Caspian Sea and their mineralizing activity. *Doklady Akad. Nauk SSSR*, 97: 329–332 (SLA, R-3955).

——, ——, A. S. TIKHONENKO, and V. I. LAMBINA. 1955. Microbial population in the region of the North Pole. *Doklady Akad. Nauk SSSR*, 101: 173–176.

——, and V. A. LAMBINA. 1955. The rate of increase in the number of microorganisms in the ocean in the region of the North Pole. *Uspekhi Sovremennoi Biol.*, 39: 366–373.

——, and M. N. LEBEDEVA. 1953. Vertical distribution of the quantity and biomass of microorganisms in the deepwater areas of the Black Sea. *Doklady Akad. Nauk SSSR*, 89: 949–952.

——, ——, and E. A. RUKINA. 1952. Distribution of the quantity and biomass of microorganisms in the sea depending on the distance from the shore. *Doklady Akad. Nauk. SSSR*, 86: 633–636 (SLA, RT-3422).

——, and E. M. MARKIANOVICH. 1954. Observations on the rate of multiplication of microorganisms in the depths of the sea. *Mikrobiologiia*, 23: 551–560.

——, ——, and E. A. RUKINA. 1954. New material on the species composition of microorganisms in the Black Sea. *Trudy Sevastopol. Biol. Stantsii*, 8: 220–287.

——, and I. N. MITZKEVICH. 1957. New class of microorganisms that dwell in the depths of seas and oceans (Krassilnikoviae). *Uspekhi Sovremennoi Biol.*, 44: 269–280.

——, and ——. 1959. Krassilnikoviae: A new class of microorganisms found in sea and ocean depths. *J. gen. Microbiol.*, 20: 1–12.

——, and M. I. NOVOZHILOVA. 1954. Are yeast organisms really sea and ocean inhabitants? *Mikrobiologiia*, 23: 669–683.

——, and E. A. RUKINA. 1947. Bacteriophage in the sea. *Doklady Akad. Nauk SSSR*, 57: 833–836.

——, and ——. 1949a. The microbiology of the Black Sea—distribution of microorganisms in the depth of the Black Sea. *Mikrobiologiia*, 18: 141–153 (SLA, RT-3674).

——, and ——. 1949b. Concerning the origin of hydrogen sulfide in the Black Sea. *Mikrobiologiia*, 18: 332–345.

——, and ——. 1949c. Reducing and oxidizing processes in the hydrogen sulfide area of the Black Sea. *Mikrobiologiia*, 18: 402–415.

——, and ——. 1952a. Biological mass of microorganisms and the rate of their multiplication in ocean depths. *Zhur. Obshchei Biol.*, 13: 346–362 (SLA, RT-2978).

——, and ——. 1952b. Microorganisms in the bottom deposits of ocean regions. *Izvest. Akad. Nauk SSSR, Ser. Biol.*, no. 6, 67–79 (SLA, RT-3259).

——, and ——. 1953. Purple sulfur bacteria in the hydrogen-sulfide-containing depths of the Black Sea. *Doklady Akad. Nauk SSSR*, 93: 1107–1110.

——, ——, and V. I. BIRIUZOVA. 1949. Conclusions concerning the species composition of microorganisms of the Black Sea. *Trudy Sevastopol Biol. Stantsii*, 7: 50–73.

——, ——, and ——. 1951a. Fate of dead organic substances in the Black Sea. *Mikrobiologiia*, 20: 90–102.

——, ——, and ——. 1951b. Microzonality in the distribution of heterotrophic microorganisms in the sea. *Mikrobiologiia*, 20: 256–265 (SLA, RT-2904).

——, ——, and M. I. NOVOZHILOVA. 1952. Distribution of heterotrophic microorganisms in oceanic depths. *Izvest. Akad. Nauk SSSR, Ser. Biol.*, no. 5, 85–101.

——, ——, and A. S. TIKHONENKO. 1950. Biomass of microorganisms at the bottom of the hydrogen sulfide area in the Black Sea. *Doklady Akad. Nauk SSSR*, 75: 453–456.

——, ——, and ——. 1952. Distribution of yeast organisms in the sea. *Zhur. Obshchei Biol.*, 13: 232–242.

——, A. S. TIKHONENKO, and V. I. BIRIUZOVA. 1958. Ultramicroscopic formations found in sea and ocean depths. *Doklady Akad. Nauk SSSR*, 119: 809–811 (AIBS Trans. 245–248).

KROKHIN, E. M. 1954. The numbers of saprophytic bacteria in Dal'noe Lake. *Mikrobiologiia*, 23: 49–52.

KUROCHKIN, B. N. 1958. A new species of sporogenous bacteria isolated from the soil of several

lakes. *Mikrobiologiia*, 27: 221–225 (AIBS Trans. 217–221).

KUZNETSOV, S. I. 1949. Adaptation of microbiological methods to the study of organic substances in water bodies. *Mikrobiologiia*, 18: 203–214.

——. 1950. Microbiological characterization of the processes of mineralization of organic substances in lakes of varying degrees of salinity. *Trudy Sapropelevoi Lab.*, no. 4, 5–14.

——. 1951. Comparative characterization of the bacterial and phytoplankton biomass in the surface water layer of the mid-Baikal Lake. *Trudy Baikal'sk Limnol. Stantsii*, 13: 217–224.

——. 1952. *The Role of Microorganisms in the Cycle of Substances in Lakes*. 299 pp. Izd. Akad. Nauk SSSR, Moscow.

——. 1954. Basic approach to the study of the ratio between the original production of organic substances in a water body and the bacterial biomass. *Trudy Problemykh i Tematicheskikh Soveshchanii Zool. Inst.*, no. 2, 202–212.

——. 1957. A review of fundamental research on the microflora of petroleum deposits. *Mikrobiologiia*, 26: 651–658 (AIBS Trans. 630–636).

——. 1959. *Die Rolle der Mikroorganismen im Stoffkreislauf der Seen*. Trans. from the Russian by A. Pochmann, Berlin.

LAMBINA, V. A. 1957. On the influence of the seasonal factor on the quantitative distribution of microorganisms in the bottom deposits of the northern Caspian Sea. *Mikrobiologiia*, 26: 218–222 (AIBS Trans. 226–230).

LEBEDEVA, M. N. 1958. Quantitative distribution of heterotrophic microorganisms in the Indian Ocean and in adjoining Antarctic Seas. *Doklady Akad. Nauk SSSR*, 121: 557–560 (AIBS Trans. 650–653).

LIALIKOVA, N. N. 1957. A study of the assimilation of free carbon dioxide by purple sulfur bacteria in Lake Belovod. *Mikrobiologiia*, 26: 92–98 (AIBS Trans. 97–104).

LIMBERG-RUBAN, E. L. 1952. Bacteria content in the water and sea-floor of the northwestern section of the Pacific Ocean. Izd. dal'nevostochnykh morei SSSR. *Zool. Inst., Akad. Nauk SSSR*, no. 3, 138–141.

LODDER, J. 1934. *Die Hefesammlung des "Centraalbureau voor Schimmelcultures." Beiträge zu einer Monographie der Hefearten. 2. Die anaskosporogenen Hefen. Erste Hälfte*. 256 pp. Verh. Akad. Wet. Amst.

LUCK, J. M., G. SHEETS, and J. O. THOMAS. 1931. The role of bacteria in the nutrition of protozoa. *Quart. Rev. Biol.*, 6: 46–58.

MANUILOVA, E. F. 1955. The relation of the variability of pelagic Cladocera to the development of bacteria in water. *Doklady Akad. Nauk SSSR*, 103: 1111–1114.

——. 1958. The question of the role of bacterial numbers in the development of Cladocera in natural conditions. *Doklady Akad. Nauk SSSR*, 120: 1129–1132 (AIBS Trans. 438–441).

MARKIANOVICH, E. 1954. Species classification of Black Sea microorganisms isolated by F. I. Kopp in 1946. *Trudy Sevastopol. Biol. Stantsii*, 8: 288–302.

MEFEDOVA, N. A. 1955. Characteristics of bacteria from the sea bed in the northwest part of the Pacific Ocean. *Mikrobiologiia*, 24: 325–331.

MESSINEVA, M. A. 1948. The composition of the microflora of salt water reservoirs of the Taman Peninsula. *Mikrobiologiia*, 17: 153–159.

NIKITINA, N. S. 1955a. The effect of the animal and plant population of the littoral on the bacterial composition of sea bottoms. *Doklady Akad. Nauk SSSR*, 102: 1031–1034.

——. 1955b. The seasonal changes of bacterial content in the bottom of the littoral of the East Murman. *Mikrobiologiia*, 24: 580–588.

——, and I. B. ULANOVSKII. 1954. The development of bacteria on steel surfaces in sea water. *Doklady Akad. Nauk. SSSR*, 98: 841–844.

NOVOZHILOVA, M. I. 1955a. The dynamics of the number and biomass of bacteria in the deep water of the Rybinsk Reservoir. *Mikrobiologiia*, 24: 710–717.

——. 1955b. The quantitative characteristics, species composition and distribution of the yeast-like organisms in the Black Sea, the Sea of Okhotsk and the Pacific Ocean. *Trudy Inst. Mikrobiol.*, no. 4, 155–195.

——. 1957. Bacterial generation time and production of bacterial biomass in the water of the Rybinsk Reservoir. *Mikrobiologiia*, 26: 202–209 (AIBS Trans. 212–218).

OPARIN, A. I. 1957. *Origin of Life on Earth*. 457 pp. Izd. 3 Akad. Nauk SSSR, Moscow. (English translation of 3rd Rev., 495 pp.) Academic Press, New York.

OPPENHEIMER, C. H., and C. E. ZOBELL. 1952. The growth and viability of sixty-three species of marine bacteria as influenced by hydrostatic pressure. *J. Mar. Res.*, 11: 10–18.

OSNITSKAIA, L. K. 1949. Activity of the cultures of sulfate-reducing microorganisms isolated from various depths of the Black Sea. *Mikrobiologiia*, 18: 525–527.

——. 1952. Prevalence of microorganisms in the Black Sea that bring about the conversion of inorganic forms of phosphorus. *Trudy Inst. Mikrobiol.*, no. 2, 157–165.

——. 1953. Distribution of putrefactive, sulfate-oxidizing, methane-oxidizing and hydrogen-oxi-

dizing bacteria in the sediments of the north Caspian Sea. *Mikrobiologiia*, 22: 399–407.

OSNITSKAIA, L. K. 1954. Numbers and biomass of bacteria in the water strata of the northern part of the Caspian Sea. *Mikriobiologiia*, 23: 571–579.

——. 1956. Influence of river waters on the number and distribution of bacteria in the water masses of northern regions of the Caspian Sea. *Mikrobiologiia*, 25: 577–583.

——. 1958. Utilization of organic compounds by a photosynthetic purple sulfur bacterium from Beloe Lake. *Mikrobiologiia*, 27: 665–672 (AIBS Trans. 653–659).

RAZUMOV, A. S. 1949. *Gallionella kljasmiensis* (n. sp.) as a component of a bacterial plankton. *Mikrobiologiia*, 18: 442–446.

——. 1955. Membrane filters and their use in the microbiological investigations of water. *Mikrobiologiia*, 24: 234–246.

RODINA, A. G. 1949. Bacteria as food of aquatic animals. *Priroda*, 38: 23–26 (SLA, RT-3425).

——. 1950. Distribution of yeast and yeast-like fungi in lakes. *Mikrobiologiia*, 19: 44–52.

——. 1952. Dynamics of bacterial biomasses in the utilization of green fertilizer of fish-breeding ponds. *Doklady Akad. Nauk SSSR*, 84: 1251–1254.

——. 1954a. Action of plant fertilization on the processes of nitrogen fixation and experiments on use of nitrogen fixation in fish ponds. *Mikrobiologiia*, 23: 684–692.

——. 1954b. Next tasks of aquatic microbiology in the field of increasing the productivity of fish breeding ponds. *Trudy Problemykh i Tematicheskikh Soveshchanii Zool. Inst.*, no. 2, 95–101.

——. 1954c. Bacteria in the productivity of the petrous littoral of Lake Baikal. *Trudy Problemykh i Tematicheskikh Soveshchanii Zool. Inst.*, no. 2, 172–201.

——. 1956. Aqueous spirilla which fix molecular nitrogen. *Mikrobiologiia*, 25: 145–149.

——, and A. P. ROMANOVA. 1954. Microbial processes in the formation of hydrogen sulfide in fish breeding ponds with green fertilizer. *Voprosy Ikhtiologii*, no. 2, 83–96.

ROMANOVA, A. P. 1958. Rate of development of bacterial flora on the littoral of Lake Baikal (according to overgrowth slide data). *Mikrobiologiia*, 27: 634–640 (AIBS Trans. 621–627).

ROZANOVA, E. P., and M. I. NOVOZHILOVA. 1958. Quantitative distribution and species composition of yeasts of the Rybinsk Reservoir. *Mikrobiologiia*, 27: 371–376 (AIBS Trans. 364–368).

ROZENBERG, L. A. 1954. The quantity of bacteria of Bering Sea bottoms; a methodical study on quantitative estimation of bacteria. *Trudy Inst. Okean.*, 11: 264–270.

——. 1958. On the zonal distribution of bacteria in the water of the far east seas and of the north-western part of the Pacific. *Doklady Akad. Nauk SSSR*, 122: 378–380.

——, and N. A. MEFEDOVA. 1956. The interrelationship between bacteria, chemical activity and zoo-organisms in the sediments of the north-western portion of the Pacific Ocean. *Mikrobiologiia*, 25: 61–65.

——, and ——. 1958. A complex investigation of the soils of the northwestern areas of the Pacific Ocean. *Mikrobiologiia*, 27: 214–220 (AIBS Trans. 211–216).

——, I. B. ULANOVSKII, and IU. M. KOROVIN. 1959. The effect of bacteria on the corrosion of uncorroded steel in narrow spaces. *Doklady Akad. Nauk SSSR*, 125: 909–912.

RUBAN, E. L. 1955. Microbiological processes in the sediments of the East Murman littoral. *Trudy Murmansk. Biol. Stantsii*, 11: 87–92.

RUKINA, E. A., and V. BIRIUZOVA. 1952. Method of preparing membrane ultrafilters free of bacterial cells for direct count. *Mikrobiologiia*, 21: 60–65.

——, and M. I. NOVOZHILOVA. 1952. Species composition of yeast organisms isolated from various depths of the Black Sea. *Trudy Inst. Mikrobiol.*, no. 2, 150–156 (SLA, RT-4642).

——, and A. S. TIKHONENKO. 1952. Comparative evaluation of the method of plating on dishes and the method of culturing of membrane ultrafilters in a bacteriological investigation of water. *Trudy Inst. Mikrobiol.*, no. 2, 180–187.

SHAPOSHNIKOV, V. N., E. N. KONDRAT'EVA, and V. D. FEDOROV. 1958. A contribution to the study of green sulfur bacteria of the genus *Chlorobium*. *Mikrobiologiia*, 27: 529–535 (AIBS Trans. 521–527).

SHTURM, L. D. 1951. Early studies by Russian scientists on the hydrogen sulfide fermentation in the Black Sea. *Mikrobiologiia*, 20: 465–470.

——. 1958. Studies on hydrocarbon assimilation by microorganisms. *Mikrobiologiia*, 27: 740–752 (AIBS Trans. 723–733).

SOKOLOVA, G. A. 1959. Iron bacteria of Lake Glubokoe. *Mikrobiologiia*, 28: 246–250 (AIBS Trans. 230–235).

——, and IU. I. SOROKIN. 1957. Bacterial reduction of sulfates in muds of the Rybinsk Reservoir. *Mikrobiologiia*, 26: 194–201 (AIBS Trans. 204–211).

——, and ——. 1958. Determination of the rate of bacterial sulfate reduction in the bottom deposits of the Gor'kovskoe Reservoir using S^{35}. *Doklady Akad. Nauk SSSR*, 118: 404–406 (AIBS Trans. 81–83).

SOROKIN, IU. I. 1955a. Processes of bacterial synthesis in silt deposits. *Mikrobiologiia*, 24: 393–399.

——. 1955b. Chemosynthetic productivity in slimy deposits. *Doklady Akad. Nauk SSSR*, 103: 875–877.

——. 1957a. Determination of the efficiency of chemosynthesis during methane and hydrogen oxidation in water reservoirs. *Mikrobiologiia*, 26: 13–16 (AIBS Trans. 11–16).

——. 1957b. The role of chemosynthesis in the formation of organic substances in water basins. I. Chemosynthesis in the water layer of the Rybinsk Reservoir in winter. *Mikrobiologiia*, 26: 736–744 (AIBS Trans. 709–716).

——. 1958a. Role of chemosynthesis in production of organic substance in reservoirs. II. Study of chemosynthesis in mud deposits with use of C^{14}. *Mikrobiologiia*, 27: 206–213 (AIBS Trans. 204–210).

——. 1958b. The role of chemosynthesis in the production of organic material in reservoirs. III. Chemosynthetic productivity in the water mass during the summer period. *Mikrobiologiia*, 27: 357–365 (AIBS Trans. 352–359).

——. 1959. The role of chemosynthesis in the production of organic matter in reservoirs. IV. Feeding of aquatic invertebrates on methane- and hydrogen-oxidizing autotrophic bacteria. *Mikrobiologiia*, 28: 916–920.

STRAKHOV, N. M. 1948. The true role of bacteria in the formation of carbonate rocks. *Izvest. Akad. Nauk SSSR, Ser. Geol.*, no. 3, 9–30.

TEPLIAKOVA, Z. F. 1952. New species of halophilic cellulose-digesting bacteria. *Mikrobiologiia*, 21: 283–289.

ULANOVSKII, I. B., and N. S. NIKITINA. 1956. The influence of putrefying aerobic bacteria on the corrosion of steel in sea water. *Mikrobiologiia*, 25: 66–71.

WINOGRADSKY, S. 1928. The direct method in soil microbiology and its application to the study of nitrogen fixation. *Soil Sci.*, 25: 37–43.

ZAVARZIN, G. A. 1955. The bacterial population of the surface film of the natural water basins of the Volga delta. *Trudy Inst. Mikrobiol.*, no. 4, 196–201.

ZAVARZINA, N. B. 1955. Study of causes inhibiting the growth of microorganisms in the body of the silt deposits in Lake Biserovo. *Mikrobiologiia*, 24: 573–579 (ATS, RJ-365).

ZENKEVICH, L. A. 1951. *Fauna and the Biological Productivity of the Sea.* Vol. 1. 505 pp. Sovet. Nauk, Leningrad.

——. 1953. Bacterial life in deep seas. *Priroda*, 42: 112–113.

ZHUKOVA, A. I. 1954. Significance of microorganisms to the nutrition of *Nereis succinea* in the Caspian Sea. *Mikrobiologiia*, 23: 46–48.

——. 1955. Biomass of microorganisms in bottom sediments of the northern Caspian. *Mikrobiologiia*, 24: 321–324 (ATS, RJ-287).

ZOBELL, C. E. 1943. The effect of solid surfaces upon bacterial activity. *J. Bact.*, 46: 39–56.

——. 1946. *Marine Microbiology*. 240 pp. Chronica Botanica Co., Waltham, Mass.

——. 1952. Bacterial life at the bottom of the Philippine Trench. *Science*, 115: 507–508.

——, and E. C. ALLEN. 1933. Attachment of marine bacteria to submerged slides. *Proc. Soc. exp. Biol., N. Y.*, 30: 1409–1411.

——, and C. B. FELTHAM. 1938. Bacteria as food for certain marine invertebrates. *J. Mar. Res.*, 1: 312–327.

——, and F. H. JOHNSON. 1949. The influence of hydrostatic pressure on the growth and viability of terrestial and marine bacteria. *J. Bact.*, 57: 179–189.

——, and C. H. OPPENHEIMER. 1950. Some effects of hydrostatic pressure on the multiplication and morphology of marine bacteria. *J. Bact.*, 60: 771–781.

——, and H. C. UPHAM. 1944. A list of marine bacteria including descriptions of sixty new species. *Bull. Scripps Instn. Oceanogr.*, 5: 239–292.

ZVYAGINTSEV, D. G. 1959. Adsorption of microorganisms by glass surfaces. *Mikrobiologiia*, 28: 112–115 (AIBS Trans. 104–108).

Translation Sources:

AIBS—American Institute of Biological Sciences, 2000 P St., N. W., Washington 6, D. C.

ATS—Associated Technical Services, P. O. Box 271, East Orange, New Jersey.

NRC—National Research Council, Library, Ottawa 2, Canada.

SLA—Special Libraries Association, John Crerar Library, 86 East Randolph St., Chicago, Illinois.

ON THE MECHANICAL IMPLICATIONS OF THE AVIAN SKULL AND THEIR BEARING ON THE EVOLUTION AND CLASSIFICATION OF BIRDS

By ALBERTO M. SIMONETTA

Istituto di Zoologia, Università di Firenze

ABSTRACT

Preliminary investigations dealing with the relationship existing between the morphology of the bird's skull and its kinetic possibilities, appear to show that the thecodont ancestors of Birds, as well as Archaeopteryx *were almost certainly akinetic. Kinetism developed early, but at least in some measure independently in the various avian orders. The amount of kinetic movement possible appears to be related to several morphological features, such as the structure of the palate, the relationship of the pterygoid and the braincase, the development of the ossification of the septum nasi, etc., which are usually considered of great taxonomic significance. It is therefore argued that the functional implications of such structures should be carefully considered when studying these features in order to ascertain the evolution and taxonomy of birds.*

INTRODUCTION

IT IS a matter of common knowledge that many birds, in order to increase their oral gape, can, in addition to the movement of the lower jaw, lift the upper jaw, which must therefore be capable of a certain amount of movement with respect to the braincase. Such skulls are known as "kinetic." A brief digression on the general structure of the bird's skull may be warranted here as an introduction to the main part of this paper.

The braincase is formed by frontals, parietals, occipital, periotics, squamosals, basisphenoid, ethmoid, and the bones often called "alisphenoids." These latter, being ossifications of the pila antotica spuria, are not homologous either with the mammalian alisphenoid (in turn homologous with the reptilian epipterygoid) or with the reptilian pleurosphenoid, (which ossifies from the pila antotica vera), and, therefore, are better termed pterosphenoids.

The braincase is continued forward by the cranial rostrum, which results from the fusion of the parasphenoid with the ossified septum nasi. The cranial rostrum is highly variable in structure in the various groups. All the bones of the braincase are completely fused and pneumatized in the adults of all birds, the pneumatization being due to diverticula of the cavum tympani. The result of the double process is a maximum of solidity, rigidity, and lightness. The prefrontals and the lacrimals too are often completely fused to the braincase.

Aside from the braincase, the remainder of the skull may be divided, from a functional point of view, into the beak and the connecting structures.

The beak is formed by the premaxillary, the maxillaries, and the nasals; again these bones are completely fused in most adult birds, and they are sometimes pneumatized.

The most delicate and complicated parts are the bones forming the palate and the jugal arch. The bony framework of the palate is composed of several bones: the palatine processes of the premaxillary, which are either suturally connected or fused with the palatine processes of the maxillaries; the vomer, which is highly variable in size, shape, and connections; and the palatines, which usually are elongated structures and which are rigidly connected both with the maxillaries and the vomer, and, in many types, also between themselves. They usually have a movable articulation with the pterygoids. Vomer, premaxillary, maxillaries, and palatines limit the internal nares.

The pterygoids are usually rodlike structures that are connected with the palatines by a movable joint, but in several species by a suture; they are almost always connected to the

quadrate by a movable articulation (in a few birds the pterygoid and the quadrate are fused). Moreover, the pterygoids are often connected by a joint or a ligament with the basipterygoid processes of the basisphenoid.

A second bridge exists between the beak and the quadrate, this being formed by the jugal and the quadratojugal, which in the adult are usually fused; and the jugal generally is fused or at least rigidly attached to the maxillary. In a few birds the quadratojugal is fused with the quadrate, but the general rule is that the jugal arch is movably articulated with the quadrate. Finally, the quadrate is always movably connected with the squamosal. For ready reference, Fig. 1 shows all these bones as they appear in the skull of a *Rhea*.

Kinetic skulls are the rule among fishes, primitive amphibians, reptiles, and birds, whilst almost all modern amphibians and mammals have a rigid, akinetic skull. [A few amphibians (*Ambystoma*, *Hypogeophis*) and a few Insectivora have a weakly kinetic skull.] However, in all classes of the Tetrapoda several groups have diverged from the primitive kinetic pattern (that called "metakinetic") either toward a reduction of kinesis or toward improvement of the kinetic mechanism.

Although it has been shown by Versluijs (1912) that much of the skull's structure is related to the type of kinesis it possesses and although it has been argued recently that, for instance, reduction of kinesis was crucial to the development of the mammalian brain (Crompton, 1955) and that in all of the Tetrapoda the structure of the middle ear is largely dependent on the variations in kinesis (Simonetta, 1957a), comparatively little attention has yet been drawn to the implications of kinesis in relation to the structure of the avian skull. The only notable exception is an important paper by Hofer (1954), which will be discussed further on.

In primitive tetrapods the skull is composed of two functional units: the braincase and the snout (this including also most of the membrane bones of the skull roof), movement between the two being allowed by the existence of ligamentous tissue binding the two segments together and by the existence of synovial joints between the basipterygoid processes, which act as pivots, and the pterygoids. Other synovial joints usually exist, as, for instance, between the vomer

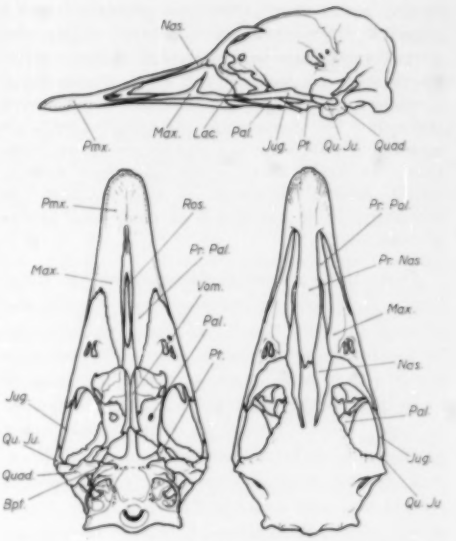

FIG. 1. *Rhea americana* (LINN.) DIAGRAMMATIC DRAWING OF THE SKULL BASED ON TWO SPECIMENS, TO SHOW THE INDIVIDUAL BONES

Pmx. = Premaxillare; Max. = Maxillare; Nas. = Nasale; Lac. = Lacrimale; Pr. Pal. = Processus palatinus ossis premaxillaris; Pal. = Palatinum; Jug. = Jugale; Pt. = Pterygoideum; Qu. Ju. = Quadratumjugale; Quad. = Quadratum; Bpt. = Processus basipterygoideus.

and the parasphenoid. Movement is produced by the muscles levator pterygoidei and protractor pterygoidei. These muscles, being attached to the braincase and to the pterygoid, when they contract move the pterygoid somewhat forward and lift its fore part. Although the amount of movement close to the basipterygoid pivot and at the flex line in the posterior part of the skull (behind the parietals) is comparatively small, this system is fairly effective in increasing the oral gape of the long-snouted animals (Fig. 2a).

A skull of this type, that is, with the dorsal line of flexure situated caudal to the parietals, is termed metakinetic; and there is ample evidence to hold that this type of kinesis is primitive.

For discussion of this point the reader may refer, besides to the basic monograph by Versluijs (1912), to the chapter on this subject by the same author in Bolk et al. *Handbuch der vergleichenden Anatomie der Wirbeltiere*, and to Goodrich (1930). Available evidence may be summarized as follows: kinesis obtains in almost all fishes both fossil and

recent; metakinetic skulls are prevalent among primitive labyrinthodonts, specialized types and modern amphibians being almost all akinetic; metakinetic skulls are again the rule in the Lepidosauria, specialized groups being sometimes amphikinetic and only a few mesokinetic (the Ophidia being all mesokinetic). Mammal-like reptiles are either metakinetic or, as for instance the specialized Anomodontia, akinetic; mammals are akinetic; birds are mesokinetic; and information on many fossil groups is insufficient.

There is no reason to discuss here the variations of kinesis in reptiles, but it must be pointed out that the dorsal line of flexure may be located further forward than in metakinetic skulls: either between the parietals and frontals or in front of the frontals. Such a line of flexure is called mesokinetic; and there are many groups, the snakes for instance, in which is occurs. Among reptiles there are, in addition to metakinetic and mesokinetic skulls, some forms which possess both lines of flexure; such skulls are called amphikinetic, and it is commonly believed that groups having a mesokinetic skull must, during their evolutionary history, have passed through an amphikinetic stage. This assumption is questionable, at least as far as birds are concerned, as will be discussed further below.

However, it should be emphasized that the basipterygoid process can function as a pivot only if one of two conditions obtains: (a) the dorsal line of flexure lies in a plane caudal to that of the basipterygoid articulation (Figs. 2a, b); or (b) the quadrate is freely movable on the squamosal (streptostylic condition) and the jugal arch is firmly bound only to the quadrate and to the snout, thus being able to slide forward and backward (Fig. 2d).

The term "arch" should better be used for temporal structures only; it should be avoided when dealing with circumorbital bones like the jugal. Since the term "jugal arch" has, however, become almost customary, this usage is retained.

Although the brain of Mesozoic reptiles was very small, some of the bipedal dinosaurs show, judging from endocranial casts, some tendency toward a relative increase in brain size. It is apparently in connection with the obvious inconvenience of a skull bending just upon the brain that the carnosaur *Antrodemus* developed a joint between the frontals and the parietals, while these, fusing with the occipital region, afforded a better protection to the brain. The squamosals, quadrates, etc., remained attached to the braincase by ligamentous tissue. While some other archosaurians are known to have been metakinetic, many, all the crocodilians for in-

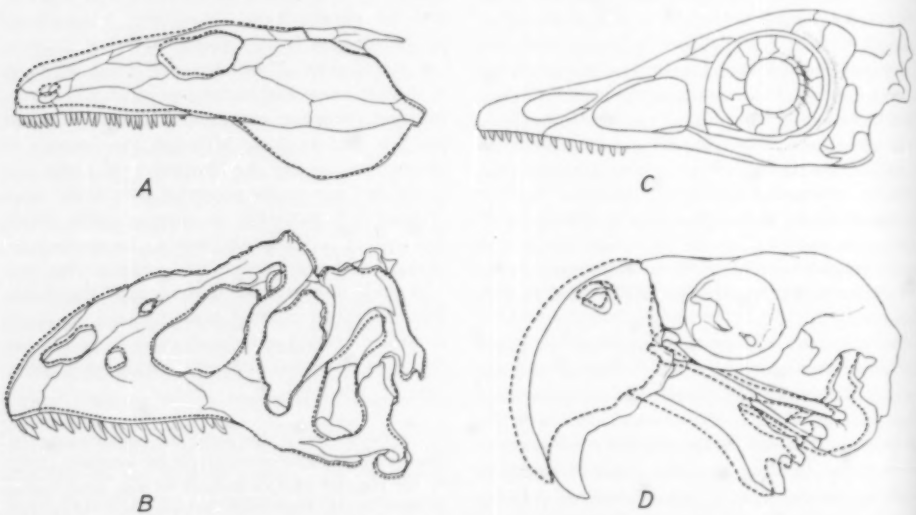

FIG. 2. DIAGRAMMATIC DRAWINGS OF THE SKULLS OF (A), a primitive labyrinthodont (B), of *Antrodemus* (C), of *Archaeopteryx* and (D) of a parrot to show kinesis (A, B, C, modified after various sources, D original).

stance, are akinetic, while for a number of species information is lacking or inadequate.

Although *Antrodemus* is obviously not in the evolutionary line leading to birds, it is of some interest inasmuch as it may afford some evidence of relation of the size and shape of the brain to kinesis.

MESOZOIC BIRDS

We may now turn to the conditions obtaining in *Archaeopteryx* (Fig. 2c). Versluijs (1910) admitted that the skull of *Archaeopteryx* may have been kinetic, and recently de Beer (1954, 1956) has accepted this hypothesis, although he did not examine it in detail. Kleinschmidt (1951) also accepted the idea of Versluijs and in his reconstruction of the skull of *Archaeopteryx* gives it a schizognathous palate, a typically kinetic adaptation, although in the London specimen nothing is left of the palate, and in the Berlin one it is so completely crushed as to make any attempt at identifying the individual bones hopeless!

There is, however, evidence which rather suggests that *Archaeopteryx* did not have a kinetic skull. The endocranial cast, as investigated by de Beer (1954), shows that the brain was morphologically rather avian, was very large if compared with that of reptiles, and that it completely filled the braincase (in reptiles and in lower classes the brain occupies only part of the braincase, and sometimes an exceedingly small part). Therefore, the possibility of a functioning metakinetic joint appears extremely unlikely: the brain would have been adversely affected by the compressions and expansions of a metakinetic braincase. A mesokinetic joint may be considered equally improbable, as a flex line between the frontals and the parietals, like that in *Antrodemus*, would have been as inconvenient to the brain as the metakinetic one, while a point between the frontals and the nasals, or further forward, is impossible. Such a joint can work only if the jugal arch is free to slide frontward; this was prevented in *Archaeopteryx* by the existence of a postorbital bone suturally connected both to the jugal and to the parietal, the jugal arch being thus completely fixed with respect to the braincase. The skull may have been streptostylic (de Beer, 1954, with some qualifications, says that it appears to have been such); but, though a quadrate movable with respect to the squamosal is essential for the type of kinesis obtaining in birds, streptostylism does not by itself mean that the skull is kinetic, since most kinetic skulls are monimostylic and the akinetic mammals are typically streptostylic.

Available evidence points, therefore, to *Archaeopteryx* being akinetic; and, thus, there is no reason to suppose that it possessed a schizognathous palate, which is primarily a kinetic adaptation. On the contrary, considering that among the Archosauria, which are admittedly the reptiles more closely related to the ancestry of *Archaeopteryx*, not a single case is known of reduction of the basipterygoid processes or of the existence of a pterygo-palatine joint, and lack of pterygo-vomerine contact is known to occur only very rarely (viz., *Plateosaurus*), and considering further that in many birds (Hesperornithiformes, Tinamiformes, Caprimulgidae, Struthioniformes, etc.) the pattern and connections of bones are close to those found in most Archosauria, there is reason to suppose that the palate of *Archaeopteryx* was similar to that found in these reptiles and in palaeognathous birds.

Kesteven (1941, 1942) maintains that the basipterygoid processes of birds, except possibly for those of the moas, are not homologous with those of reptiles. However, Crompton (1953) has vindicated this homology, and it can no longer be doubted.

The next step in the acquisition of a kinetic skull was attained by the breaking down of the postorbital (suborbital) bar: the postorbital bone disappears and a ligament at most is left in its place. This allows for a free movement of the jugal arch, which is moved forward by the quadrate, which in turn is moved by the musculus protractor quadrati (musculus orbitoquadratus). At the same time the palatal complex is moved forward by the synergic action of the musculus protractor pterygoidei, which moves the pterygoids frontward, and by the quadrate pulling, at the same time, the pterygoid and the jugal arch.

The amount of movement possible, however, is still small: effective kinesis in a skull like that of birds implies that the pterygoid, when moving forward, increases its distance from the basisphenoid, and that cannot be considerable as long as a primitive basipterygoid-pterygoid articulation exists. The basipterygoid processes are primarily pivots so that once the *Bewegungslinie* moves in front of them, thus depriving

them of their original function, they are liable to become a hindrance and may be lost, as for instance in snakes and in many birds.

The evolutionary stage represented by the reduction of the postorbital bar, while the basipterygoid articulation was retained in its primitive form, was already reached in upper Cretaceous times (*Hesperornis*) and is retained in a number of modern genera. This condition has obvious mechanical disadvantages which have been dealt with in various ways.

Hesperornis could subsist on fishes owing to what may be termed an emergency device: the development of a joint in the lower jaw between the angular and the splenial, which allows the jaw to bend, thus increasing the mouth gape. The same system is developed in the caprimulgid *Nyctisyrigmus* (Fourie, 1956), which obviously is an example of convergent evolution; *Nyctisyrigmus,* indeed, possesses a dromaeognathous palate with primitive basipterygoid processes articulating by a synovial joint with the pterygoid, and has an exceedingly restricted kinesis.

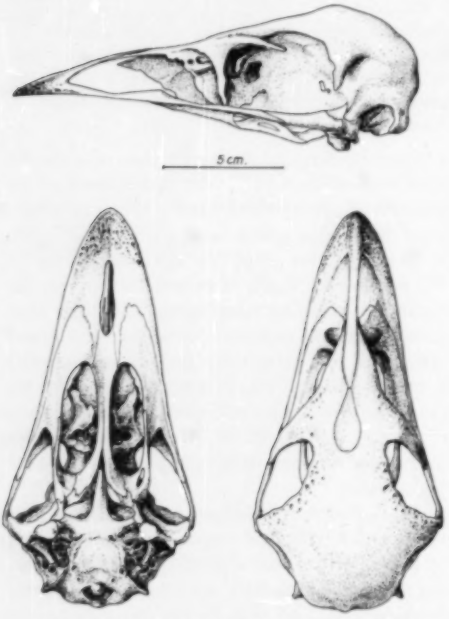

FIG. 3. SKULL OF *Dromaeus novaehollandiae* (LATHAM).
Note that the palatine and pterygoid are in contact. This obtains in most of the specimens examined, contrary to McDowell's findings. Original.

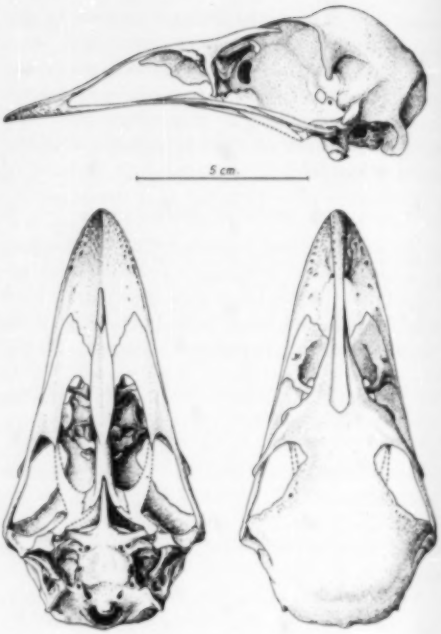

FIG. 4. SKULL OF *Dromaeus peroni* ROTHSCHILD (original: specimen of the Florence Museum, jugal, quadratojugal and maxillary after the skull in Paris, vomer after spec. B 6814 Museum of Adelaide)

Very little is known of Cretaceous and lower Cenozoic birds' skulls other than *Hesperornis*; and, therefore, we are bound to rely on living and recently extinct species for evidence.

DROMAEOGNATHY

In a previous study of the kinesis of dromaeognathous birds (Simonetta, 1957b) I have shown that on the basis of skull morphology and kinesis these birds may be divided into three distinct groups: one including the Casuariformes, the Dinornithiformes, and the Apterygiformes; one including *Struthio* and *Aepyornis* (no material of *Mullerornis* has been so far available to the author); and one including the Tinamiformes and Rheiformes. The differences in kinesis between these groups are the following. The first group (Casuariformes, Dinornithiformes; Apterygiformes; (Figs. 3–7) includes both akinetic and weakly kinetic species. In the kinetic species kinetism functions by lifting the

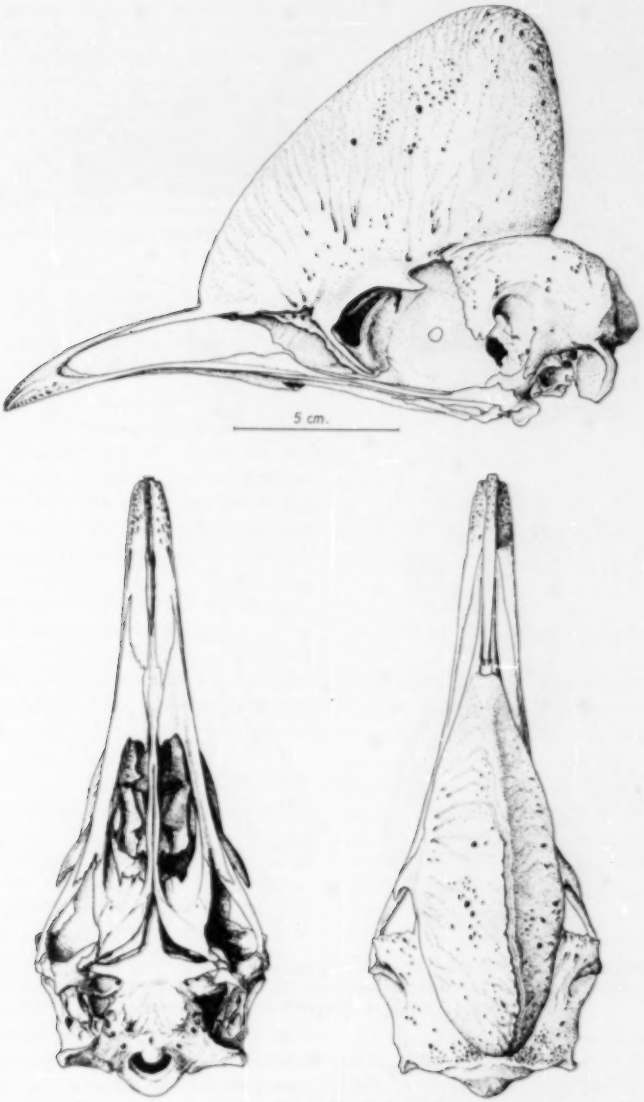

FIG. 5. SKULL OF *Casuarius casuarius* (Original) (LINNAEUS)

premaxillary off the nasals (which, by their structure cannot bend); lifting is allowed by the fair amount of connective periostium between the nasal process of the premaxillary and the nasals, which are deeply grooved to lodge it. This groove, in the kinetic species, is very large in comparison with the nasal process of the premaxillary, the syndesmosis between them being, therefore, fairly loose. In the akinetic species of the group distinct traces of this system can always be found. The jugal arches, the palatines, and the vomer all take part in the transmission of the pull of the pterygoids and of the quadrates.

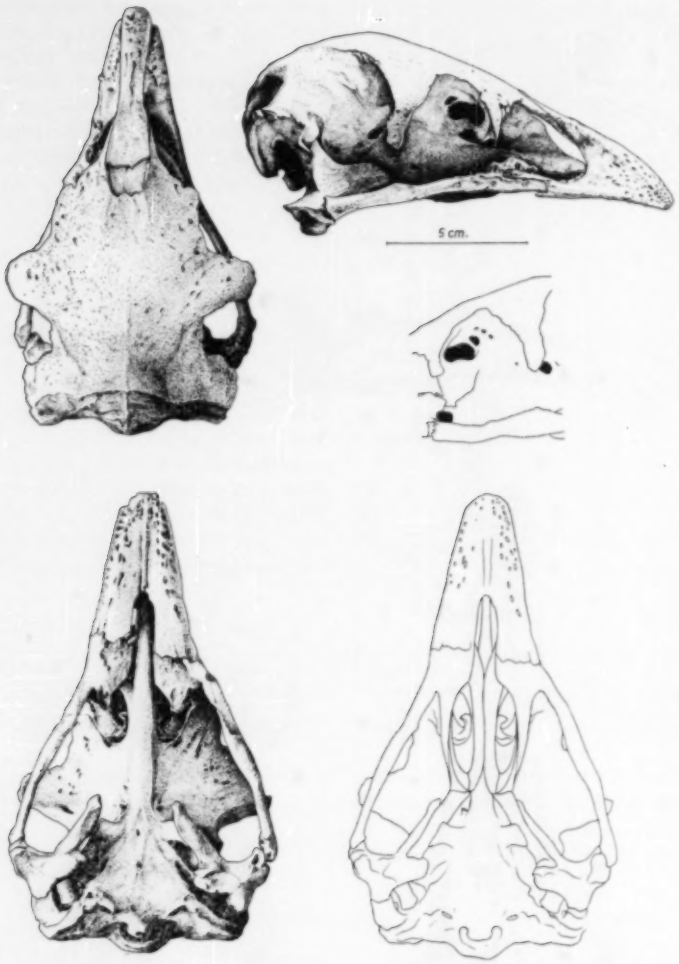

FIG. 6. SKULL OF *Anomalopteryx didiformis* (OWEN) (Original. The specimen figured is the type of *Dinornis parvus* Owen. It has been chosen for figuring also because Owen's original plate is incorrect in several details.

In addition to the *Moa* material studied in my paper of 1957, I have had the opportunity of checking my results on the skulls in the collections of the British Museum; I take the opportunity to thank the authorities of the British Museum for the facilities which they have offered for studying this and the *Pezophaps* material quoted further on.

The second group (*Struthio* and *Aepyornis*; Figs. 8, 9) includes weakly kinetic (*Struthio*) and akinetic (*Aepyornis*) genera. In *Struthio* kinesis obtains by a gentle bending of the nasal process of the premaxillary and of the underlying nasals; no definite line of flexure exists. The stress prompting movement is transmitted only by the jugal arch and by the palatines, since the vomer usually does not touch the pterygoid or the palatines. In the akinetic *Aepyornis* (all three species of the genus were investigated) the morphology of the palate is close to that of *Struthio* and especially close to that of the 34-day-old embryo described by Webb (1957). Indeed, the main differences be-

tween *Aepyornis* and the adult *Struthio* are in the much longer vomer, which is extensively fused with the pterygoid, and is united to the palatine processes of the premaxillary by long sutures, so that the palate is solidly roofed in front. Kinesis may be excluded because of the complete rigidity of the dorsal surface of the beak. Although the ancestors of *Aepyornis* might have been weakly kinetic, speculation on the role of the vomer in it would merely be guesswork.

In only 3 out of 36 skulls studied by Webb (1957) and in none of those examined by the author has the vomer slight contact with the pterygoid; therefore this contact must be regarded as very rare.

In the third group (Tinamiformes and Rheiformes; (Figs. 10, 11) the vomer again plays a significant role in kinesis; but while in the Tinami there is a typical line of flexure running across the nasals and the nasal process of the premaxillary, this line in *Rhea* is not distinct and the situation approaches that in *Struthio*. But the whole structure of the skull and particularly that of the palate suggests that it may easily be an hypertrophied derivative of a tinamu-like skull. The arrangement arrived at in my investigation is consistent with that of McDowell (1958) except for the position of *Aepyornis*, for which, however, he had to rely on inadequate descriptions.

It was suggested by Simonetta (1957b) that this evidence could be interpreted as follows. During lower Cretaceous times the postorbital bone dwindled into a ligament, thus permitting some mobility for the jugal arch and thereby kinesis. This, however, was restricted by the unspecialized condition of the basipterygoid articulation. The problem of the movement of the beak was then solved in two different ways: one stock did it by loosening somewhat the attachment of the premaxillary to the nasals; this stock became isolated in the Australian region, took to ground-living, and evolved into the emus, cassowaries, moas, and kiwis. The other possible device for bending the beak, by means of a line of flexure across the beak, was adopted by other birds. This system is potentially more effective, should the basipterygoid process become reduced or specialized; and, therefore, there is no reason to exclude the possibility that it may have developed independently in various groups. It appears, indeed, from the very different mechanical adaptations of the palate and beak in the various avian orders, that an increase in cranial kinesis was obtained independently in the various groups, employing different devices. This will be the subject of the following pages, but before dealing with it, a brief discussion of two recent and important papers on the evolution of walking birds by de Beer (1956) and by Webb (1957) is necessary, since these authors' conclusions are much at variance with my own, while those reached by Starck (1955) and by Lang (1956), though based on different lines of evidence, are compatible with my own conclusions.

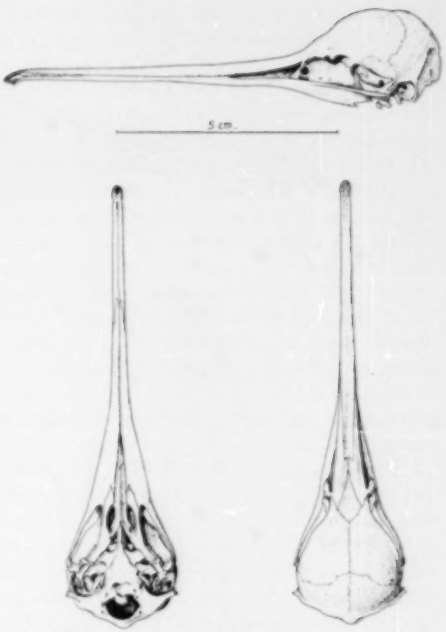

FIG. 7. SKULL OF *Apteryx oweni* GOULD (original)

De Beer gives a general review of the problem and concludes that the dromaeognathous birds probably have been derived by neoteny from presumably neognathous flying ancestors. His evidence for considering these birds as deriving from flying ancestors is quite conclusive and may be regarded as final. As for neoteny, de Beer calls attention to the pterylosis, to the persistence of cranial sutures and to the structure of the palate. While pterylosis lies outside the subject matter of this paper and while I agree that it may well be a neotenic character, I am

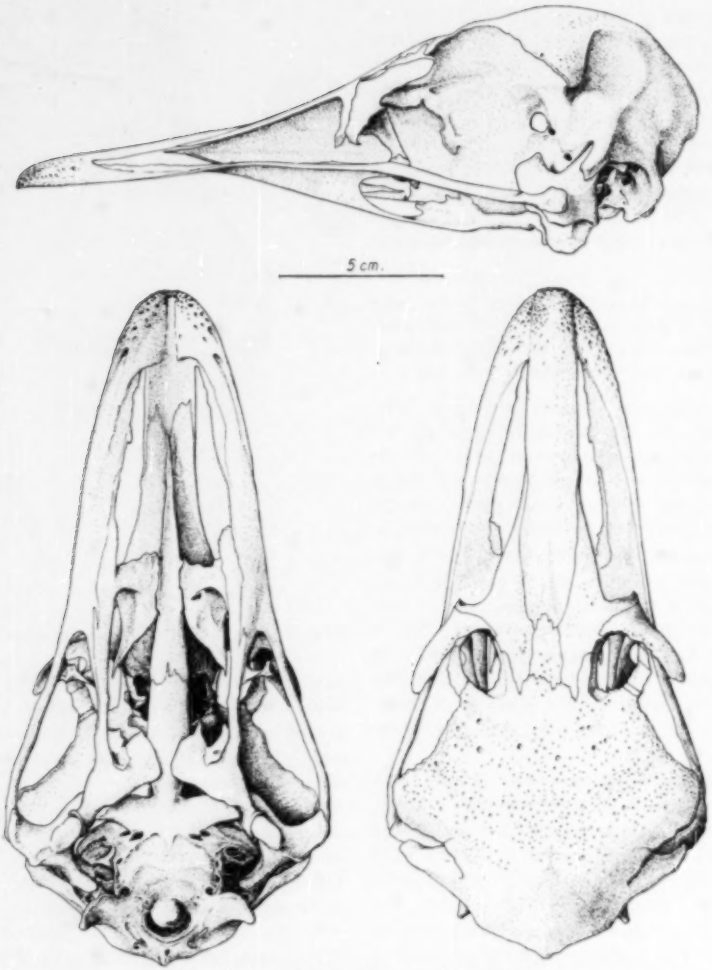

FIG. 8. SKULL OF *Struthio camelus* LINNAEUS

not so certain about the significance of the delayed disappearance of sutures; and I am definitely not convinced by de Beer's argument about the palate. An alternative explanation of the long retention in the Dromaeognathae of the sutures of the facial bones (those of the braincase are always completely fused in the fully adult animals) may be that since kinesis is either restricted or absent, the additional rigidity afforded by fusion is not essential, and that the Dromaeognathae (except the Tinami) are animals that continue to grow for a considerable time, while the Neognathae complete their growth generally in a year or less. This long period of growth may be neotenic, but as the rapid completion of growth in the Neognathae is obviously a specialization in contrast to the reptiles, which continue to grow for their whole lives, and to *Archaeopteryx*, which apparently had persistent sutures, it may be truly primitive too. As for the palate, I shall point in the following pages to the evidence afforded by the Neognathae to indicate their derivation from palaeognathous ancestors.

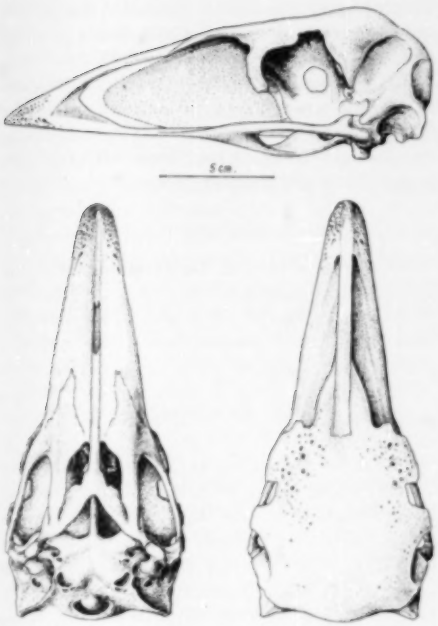

FIG. 9. SKULL OF *Aepyornis hildebrandti* BURCKARDT (Original, reconstruction after two specimens in Paris, casts and photographs)

It may be recalled that von Blotzheim (1958) gives a fresh discussion of the pterylosis and of the morphology of the girdles of the Dromaeognathae. He concludes that these birds were probably derived from advanced coelurosaurids, while the flying birds were derived from some primitive coelurid. Discussion of this hypothesis would be out of place in a paper concerned solely with the skull, but it must be said that skull morphology points to a monophyletic origin for all birds and to their branching off from the Pseudosuchia, possibly close to the origin of the saurischians.

Coming to Webb's paper, we find this author, after a careful study of the ontogeny of the skull of the ostrich, reaching the following basic conclusions: (a) the skull of the other dromaeognathous birds may be derived by neoteny from an ostrich-like skull; (b) the skull of the ostrich may be derived by neoteny from a neognathous type. To these conclusions the following criticisms may apply. First, Webb makes no mention of the different mechanical implications of the skulls of the various species, and these differences cannot be explained by his theory. Second, his hypothesis of the origin of the flexure of the pterygo-palatine bar from an ostrich-like straight original one is denied (a) by the palate of *Aepyornis* (not mentioned by Webb) which possesses both a perfectly straight pterygo-palatine bar and an extensive fusion between the pterygoid and the vomer (Fig. 9), thus showing that the pterygo-palatine bar need not have bent to allow contact between the pterygoid and the vomer; (b) by the manipulation of the ostrich palate that proves that stresses such as those described by Webb would bend the pterygo-palatine bar outward rather than inward as required by his own theory. It appears, indeed, that the palato-maxillary ligament to which Webb calls attention may only be effective in opposing an outward bending of the palatine and not the reverse. Another point to which Webb calls attention, the disappearance in the adult ostrich of the palatine process of the premaxillary, which in the embryo contacts with the vomer and which is retained in all the other Palaeognathae, appears rather to support the opposing theory. Since palatine processes of the premaxillary exist in the great majority of birds

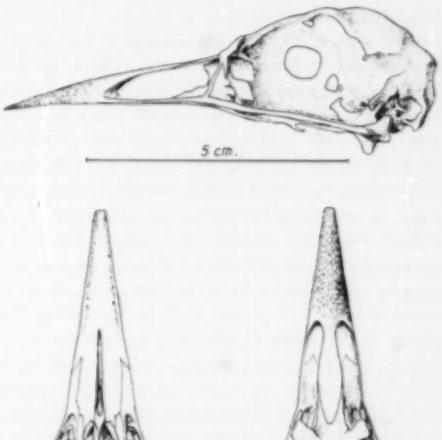

FIG. 10. SKULL OF *Rhea americana* (LINNAEUS)

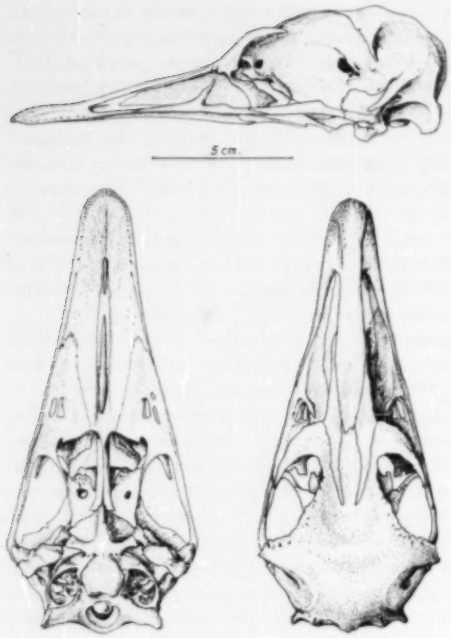

FIG. 11. SKULL OF *Tinamus* SP. (original)

and in reptiles as well, their reduction in the ostrich should be interpreted as a peculiar specialization of this species. The contact between the premaxillary and the vomer is primitive in the Tetrapoda and will fail to obtain provided that either the palatine flanges of the premaxillary become reduced (which we have seen to be a specialization), or provided the vomer becomes sufficiently short (which again appears to be a specialization obtaining in different ways in the various avian orders). Webb calls attention to another character of the skull as supporting his thesis, namely, the failure of the external nares and of the preorbital fossa to become separated by a bony bridge. However, this character does not hold true for *Hesperornis*, for the Tinami, for *Rhea* (where in fully adult animals the bony bridge fails to be complete for a matter of 2–3 mm, which morphologically is of no significance), or for *Apteryx*.

It is perfectly true, as was pointed out by McDowell (1948), that the dromaeognathous palate is not an entity which may be defined morphologically; but since the total pattern of bones appears to be primitive, there is the possibility of defining it if we bring into the picture the absence of any cranio-facial fissure. I think that we are justified in reverting to Pycraft's term "Palaeognathae" not as a taxonomical term, but as defining a morphological pattern typified by lack of a cranio-facial fissure, and by contact (except in the ostrich) of the vomer with both the premaxillary and the pterygoids.

NEOGNATHY

We may now turn to the development of the neognathous condition. To increase the efficiency of the kinetic apparatus three basic devices have been employed; but, as we shall see, there is such variation in all of them that their significance in relation to a possible monophyletic origin of the Neognathae is questionable.

The three devices are: (a) the development of a cranio-facial fissure (which results in the beak being attached to the braincase only by its dorsal part) that in most birds is flattened so that it may freely bend (Bewegungslinie); (b) either reduction or modification of the basipterygoid processes such as to increase the range of movements of the pterygoids; (c) the development of a joint either between the pterygoids and the palatines or within the pterygoids (the fore-part of these bones becoming detached, the detached part being called hemipterygoid, and this later fusing with the palatine). It must be stressed that these devices are the only possible ones that can operate in increasing cranial kinesis.

The existence of true hemipterygoids has been recently challenged, but de Beer (1956) has vindicated it with very good evidence.

As for the cranio-facial fissure, little can be said at present. It certainly is a character of great importance; but its ontogeny is known, so far as I am aware, only for three genera: *Anas* (Swart, 1946), *Spheniscus* (Crompton, 1953), and *Nyctisyrigmus* (Fourie, 1956); and in these genera the fissura cranio-facialis develops in two very different ways. Considering that the fissura cranio-facialis is absent in the Charadrii and that the morphology of the sphenoid rostrum is highly variable in the several orders, it appears that until the ontogeny of many more species is known it will be impossible to estimate the phyletic significance of the fissura cranio-facialis.

Specialization of the basipterygoid articulation and morphology of the palate may be considered together. There is ample evidence to suggest that in its development convergence and parallel evolution may have played significant roles. Amongst these the following may be quoted as particularly significant.

In the Caprimulgiformes there are genera (*Caprimulgus*, *Nyctisyrigmus*) which possess basipterygoid processes articulating by synovial joints with the pterygoids. The pterygoid does not break, so that there is no hemipterygoid; the pterygoid keeps, in the adult, its contact with the vomer as in palaeognathous birds. However, the palatines expand below the pterygoid so that the palatines are separated by only the ossified mediopalatine cartilage, which in *Nyctisyrigmus* becomes fused with the palatines, and so accounts for the usual description of the palate as desmognathous. This desmognathism is evidently of an entirely different significance from that of the Anseres, for example, where, in ontogeny, the pterygoid never touches the vomer and there is no mediopalatine. In the above-mentioned caprimulgids kinesis is almost absent (Fourie, 1956). In another genus of the same order (*Steatornis*) the basipterygoid processes are present, but the articular facet is disproportionately larger than that of the pterygoid. Since the articulation, therefore, is very loose, there is a joint between the pterygoids and the palatines, which seems to be due to the breaking off of hemipterygoids (Parker, 1889). In another genus (*Podargus*) the basipterygoid processes are quite abortive, articulation between the pterygoids and palatines being present.

In the Striges we meet again with basipterygoid processes; and again we find indications of reduction in some genera and of specialization in others. In *Carine* the basipterygoid-pterygoid articulation is closely similar to that of *Nyctisyrigmus*; but in *Tyto* the articular surface of the basipterygoid is, as in *Steatornis*, exceedingly wide in comparison with the corresponding process of the pterygoid which obviously indicates a very loose joint. Finally, in some species of *Bubo* the basipterygoid process and the corresponding process of the pterygoid are represented by thin lamellae which fail to connect and are linked by a ligament. In all of the Striges the cranial rostrum is exceedingly short, thereby contributing to effective kinesis. The palate is intermediate between the schizognathous and the desmognathous type.

In the Falconiformes we meet with every possible morphologic stage from perfect basipterygoid processes articulating with the pterygoids (Serpentarii, Cathartae; Pycraft, 1902) which accompany an incompletely desmognathous palate, to the total absence of the basipterygoid processes through all possible stages of reduction, while the palate is schizognathous, desmognathous, or intermediate between the two (Falcones; Pycraft, 1902).

Among the Columbiformes the palate is consistently schizognathous, and basipterygoid processes are almost invariably present, but exceedingly variable. For instance, in *Columba* they articulate with the pterygoids, whilst in *Pezophaps* (Fig. 12) they do not touch the pterygoids and range, in the different individuals, from well formed, even if small structures, to tiny, hardly distinct structures. Finally, in *Didus* basipterygoid processes are entirely absent.

In the Palliformes, again, the basipterygoid processes vary from rather large structures articulating by a synovial joint with the pterygoids (*Turnix*; Parker, 1873) to their complete absence in typical rails. Kinesis appears to be more restricted in *Turnix*, where the palate is intermediate between the schizognathous and the aegithognathous type, than in the true rails (*Fulica etc.*) which have a true schizognathous palate. Many other examples of similar variations of the palate and of the basipterygoid articulation might be added.

Many birds have dispensed entirely with basipterygoid processes, which at most remain represented (as, for instance, in *Spheniscus*) by a ligament which obviously cannot disturb kinesis.

Even the articulation of the pterygoid with the palatine is subject to much variation. For instance, it does not develop in the Pici (where the pterygoid continues in the adult to extend to the vomer, lying on the palatine) which have a reduced kinesis. The development of the pterygo-palatine joint may be due to failure of the pterygoid to reach the vomer (true pterygo-palatine diarthrosis), as in the Anseres and Galli, or to the breaking off of the hemipterygoid (intrapterygoid diarthrosis) as in the Opisthocomi, which are commonly believed to be related to the Galli.

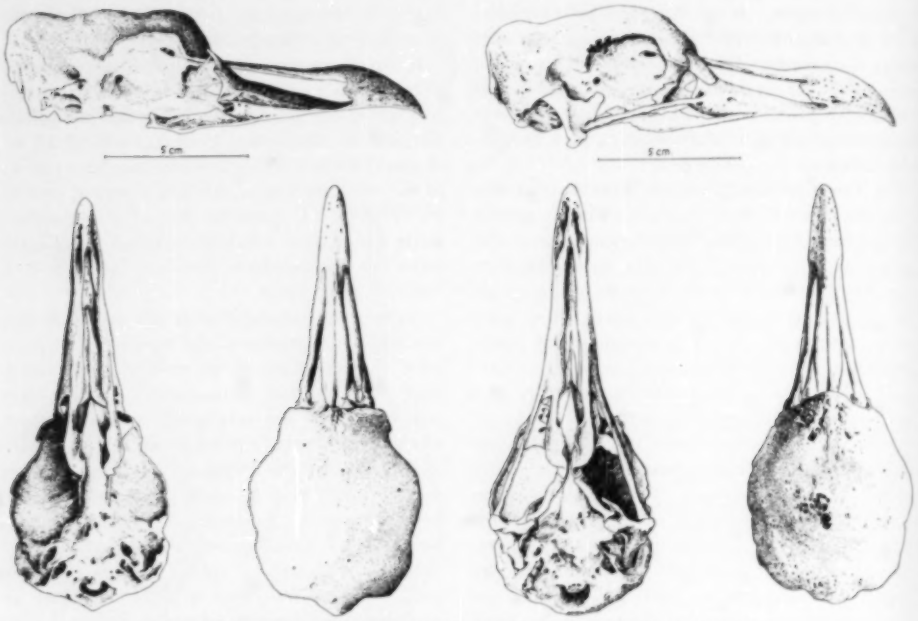

FIG. 12. SKULLS OF TWO SPECIMENS OF *Pezophaps solitarius* (GMELIN) variability of basipterygoid processes. Original. Specimens in the British Museum

The Galliformes are considered as typically schizognathous, but *Crax* at least is desmognathous (Parker, 1889).

CONCLUSIONS

The available evidence appears to suggest that while pure descriptive morphology of birds' skulls may well be misleading in assessing the mutual relationships of the various avian groups, a fresh study of these skulls in the light of modern functional morphology may adduce valuable evidence of the evolutionary trends of the various avian lineages, thus being of considerable help in establishing the systematics of birds on a more satisfactory basis.

So far my conclusions agree with the fundamental tenet of Hofer (1954); it is, therefore, appropriate to discuss it briefly. It is a very important contribution which first, and so far alone, stresses to the right degree the need of keeping in mind the mechanical framework of any avian skull when studying its morphology.

Hofer is extremely cautious about drawing conclusions that relate to phylogeny, and in his paper he points out the possibility of alternative explanations for each assemblage of morphologic features that he considers. Comparison of his text with the hypotheses proposed in this paper will show, however, that there are some points of disagreement. These may be summarized as follows: Hofer maintains that the reduction of the olfactory apparatus has played a major part in allowing the development of kinesis, and particularly of the fissura craniofacialis. However, it would seem that if the olfactory structures in the heads of birds (except in *Apteryx* and the moas) appear diminutive, this seems to be due to the increase of the eyes and, in the brain, to the development of the hemispheres, rather than to true reduction of the nasal capsule and of the olfactory bulbs. The disappearance of two more structures is attributed by Hofer to the development of the avian type of kinesis, the ectopterygoid and the epipterygoid. This hypothesis could be true, but there seems to be an alternative explanation. The epipterygoid is lost in the majority of the archosaurians; and, when present as in the Phytosauria and a few saurischians, it is a tiny and short bar which fails to reach the vault of

the skull. It may, therefore, be that the epipterygoid was lost by the ancestors of the modern birds long before they had evolved to the *Archaeopteryx* stage and thus long before evolving the avian type of kinesis. The loss of the ectopterygoid may similarly be unrelated to the development of mesokinesis; its presence would prevent the working of the pterygo-palatine joint, but would not matter much in the types devoid of such a joint. Indeed, the ectopterygoid was reduced to a diminutive structure almost fused to the external flange of the pterygoid in several archosaurians; and it may well be that the disappearance of the ectopterygoid is related to the disappearance of the external flange of the pterygoid itself, which may be independent of mesokinesis.

As to the differences in relationship between the palate and the parasphenoid rostrum in birds and reptiles, Hofer may have overestimated them, since there are a number of recent reptiles in which the palate is connected with the parasphenoid by a synovial joint just like that of birds.

There is a considerable difference between Hofer's statement that dromaeognathous birds are all rhinchokinetic and my own account of kinesis in these birds. In support of my account, I may call attention to the fact that, as far as the Tinami and *Struthio* are concerned, my results are in agreement with those of the histologic investigations of De Villiers (1946) and Webb (1957). As for the Casuariformes, differences are more formal than real, since their skull, when kinetic, is rhinchokinetic in the sense of Hofer (1949). But, in view of the fact that there are so many differences in the actual operation of kinesis in the various orders, I doubt if the terms pro- and rhincho-kinetic actually are morphologically meaningful; it might be better to abandon them in favour of Versluijs' older and comprehensive term mesokinetic, while bearing in mind that in reptiles and birds there actually exist a score of different types of mesokinesis. The moas and *Aepyornis* were not considered by Hofer.

Hofer pays much attention to holorhiny and schizorhiny. This certainly is an important point; and if it has not been dealt with in this paper, it is because the material which has been available to me for investigation so far was insufficient to enable me to draw even tentative conclusions. Only for the Palaeognathae (typologically speaking, as they appear not to form a systematic unit) material was satisfactorily representative, but it appears that discussion of this point based only on these genera might be misleading and has therefore been avoided.

While this paper was in press the following papers were seen, but, as their contents did not necessitate amendments of my text, it did not seem useful to discuss them. This will be done in another paper now in preparation.

BEECHER, W. J. 1951. Adaptations for food-getting in the American blackbirds. *Auk*, 68: 411–440.

BOCK, W. J. 1959. Preadaptation and multiple evolutionary pathways. *Evolution*, 13: 194–211.

——. 1960. The palatine process of the premaxilla in the Passeres. A study of the variation, function, evolution and taxonomic value of a single character throughout an avian order. *Bull. Mus. comp. Zool. Harv.* 122: 361–488.

FISHER, H. I. 1955. Some aspects of the kinetic in the jaws of birds. *Wilson Bull.*, 67: 175–188.

LIST OF LITERATURE

CROMPTON, A. W. 1953. The development of the chondrocranium of *Spheniscus demersus* with special reference to the columella auris of birds. *Acta zool., Stockh.*, 34: 71–146.

——. 1955. A possible explanation for the origin of the mammalian brain and skull. *S. Afr. J. Sci.*, 52: 130–133.

DE BEER, G. 1954. *Archaeopteryx lithographica*. London, i–xi, 64 pp.

DE VILLIERS, C. G. S. 1946. The relations of the vomer and palatoquadrate bar to the cranial rostrum in the Tinamu (*Crypturellus* sp.). *Ann. Univ. Stellenbosch*, 24, A: 21–39.

FOURIE, S. 1956. A contribution to the cranial morphology of *Nyctisyrigmus pectoralis* with special reference to the palate and cranial kinesis. *Ann. Univ. Stellenbosch*, 31, A, (1955): 179–215.

GOODRICH, E. S. 1930. *Studies on the structure and development of Vertebrates*. MacMillan, London (reprinted 1958 by Dover).

HOFER, H. 1949. Die Gaumenlücken der Vögel. *Acta zool. Stockh.*, 30: 209–248 (not seen, quoted after Hofer, 1954).

——. 1954. Neuere Untersuchungen zur Kopfmorphologie der Vögel. *Acta XI Congr. Internat. Ornithologici*, (*Experientia*, Suppl. III), pp. 104–137.

KESTEVEN, H. L. 1941. On certain debatable questions in cranioskeletal homologies. *Proc. Linn.*

Soc. N. S. W., 66: 293–334 (not seen, quoted after Crompton, 1953, and Fourie, 1956).

——. 1942. The ossification of the avian chondrocranium with special reference to that of the Emu. *Proc. Linn. Soc. N. S. W.*, 67: 213–237 (not seen, quoted after Crompton, 1953).

KLEINSCHMIDT, A. 1951. Uber eine Rekonstruktion des Schädels von *Archaeornis siemensis* Dames 1884 im Naturhistorische Museum, Braunschweig. *Acta X Congr. Internat. Ornithologici* (1950), pp. 631–635.

LANG, C. 1956. Das Cranium der Ratiten mit besonderer Berücksichtigung von *Struthio camelus*. *Z. wiss. Zool.*, 159: 165–224.

MCDOWELL, S. 1948. The bony palate of Birds. Part I: the Palaeognathae. *Auk*, 65: 520–549.

PARKER, W. K. 1873. On aegithognathous birds, Part 7. *Trans. zool. Soc. Lond.*, 9: 289–352.

——. 1889. On the osteology of *Steatornis caripensis*. *Proc. zool. Soc. Lond.*, 1889: 161–190.

PYCRAFT, W. P. 1902. Contributions to the osteology of birds; Part V, Falconiformes. *Proc. zool. Soc. Lond.*, 1902: 277–320.

SIMONETTA, A. 1957a. Sulla possibilità che esistano relazioni tra meccanismi cinetici del cranio e morfologia dell'orecchio medio. *Mon. Zool. It.*, 65: 48–55.

——. 1957b. Osservazioni sulla meccanica del cranio degli uccelli dromeognati. *Atti Soc. tosc. Sci. nat., ser.* B: 140–167.

STARCK, D. 1955. Die endokraniale Morphologie der Ratiten, besonders der Apterygidae und Dinornithidae. *Morph. Jb.*, 96: 14–72.

SWART, P. J. 1946. Die ontogenese van die "desmognate" monddaktipe by *Anas*. *Ann. Univ. Stellenbosch*, 24, A: 1–19.

VERSLUIJS, J. 1910. Streptostylie bei Dinosaurien, nebst Bemerkungen über die Verwandschaft der Vögel und Dinosaurier. *Zool. Jber.* (Abt. Anat.), 30: 175–270.

——. 1912. Das Streptostylie-Problem und die Bewegungen im Schädel bei Sauropsiden. *Zool. Jahrb., Suppl.* 15, Vol. 2: 545–716.

WEBB, M. 1957. The ontogeny of the cranial bones, cranial peripheral and cranial parasympathetic nerves, together with a study of the visceral muscles of *Struthio*. *Acta zool., Stockh.*, 38: 81–203.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

HOW SELECTION MAY CHANGE A MENDELIAN POPULATION

BY JAY L. LUSH

Iowa State University

A Review of THE GENETIC BASIS OF SELECTION. *By I. Michael Lerner. John Wiley & Sons, New York; Chapman & Hall, London.* $8.00 xvi + 298 pp.; ill. 1958.

This book is about selection as a process, considered from the material basis on which it operates. It is not about evolution, except remotely. Most of it concerns moderate changes in populations. Mention of differences between species is rare. Polyploid and asexually reproducing populations are intentionally omitted.

The title is well chosen. The author stands on the knowledge which geneticists have aquired, or think they have aquired, in the 60 years since Mendel's law was rediscovered, and, in effect, he asks: On the basis of how this mechanism works under this or that set of circumstances, what changes can we expect selection to cause? And if those results are not obtained when the experiment is tried, what are the most plausible explanations for that? Naturally this procedure suggests questions or gaps in present genetic knowledge which seem most to need further investigating. Those mentioned in various places include the following: (a) effects of intermittent or cyclic selection with relaxation of selection from time to time; (b) the search for highly hereditary marker characters which indicate some important but more difficultly or uncertainly observable characters; (c) signals which will indicate when a ceiling is being approached closely or when, for other reasons, a hitherto successful breeding plan should be changed; (d) measuring more precisely the value of various selection and mating plans; (e) considering how the genetic correlations between various characters change when those characters are changed by effective selection pressure; (f) the possibilties in immunogenetics; (g) increasing or renewing the effectiveness of selection by using unusual environments or stresses; and (h) ways of evaluating individual breeding values more accurately.

Lerner's approach and choice of words are extremely philosophical, in the sense that he seems always to strive intensely to state the truths in form general enough to encompass as nearly as possible all contingencies and all situations, and yet retain accuracy. This leads to a strong emphasis on definitions, with attempts to make those as broad as possible and yet retain accuracy. In spite of the resulting strong emphasis on definitions, these slip at times into some vagueness. The more fully one tries to describe nature, the more one's definitions keep getting fuzzy at the edges. It is a bit like trying to describe accurately the dimensions and shape of a cumulus cloud. The cloud is real; we know it is there; we agree on an approximate description for it; but the edges and the details keep changing and dissolving even while we work at describing its details!

The author's style is clear and, in the main, easy reading, although it is cluttered a bit with more words and longer words than would make for maximum clarity and ease in reading. "A greater number of" is often used where "more" would do better. "There is" and "There are" are used again and again, where wading more directly into the subject would be simpler and shorter. The gain from using "morphism" and its combinations so much seems dubious, except to emphasize a distinction between what were once called quantitative and qualitative characters, or between "continuous" and "discontinuous" variation. With each decade of research this distinction is seen more clearly to reflect only the size of the effects which the individual genes have, or the crudity of the devices by which we measure or describe what we observe. Basically, what genetic difference is

there, for example, between saying that a population is polymorphic for color and saying that it is variable in weight or in stature?

"'Coadaptation" is used again and again without any precise definition, so far as can be seen, in spite of nearly 3 pages devoted to it in Chapter 1. For instance, we read on pp. 33 and 34 of coadaptation; "In general, it is based on selective processes which build up and maintain a gene pool of alleles acting in a synergistic manner to produce desirable genotypic combinations and which endow the genetic system of a population with the property of integration (Darlington, 1939)." And a little later Lerner says, "The general notion may be expanded to embrace all types of mutual adjustments between the various elements of the genetic system (Darlington's, 1956, mutual selection)." Operationally does "coadaptation" really mean anything more than the truism that the various genes or other parts of an individual must function well together if that individual is to prosper biologically? Perhaps it emphasizes usefully that the selection coefficients for genes can vary in size and even in sign, depending on what other genes are present, but is that anything more than saying that epistasis exists?

Readers who cherish any lingering hope that the English language can remain simple grammatically or who learned to diagram sentences under the old-fashioned teaching of 40 or more years ago can hardly repress a shudder at the prospect of parsing such a sentence as the following, in final reference to an example: "Above all, its moral lies in the demonstration of the fluidity of interrelations between the various elements of co-adaptation over a long pull in the integration of the contents of a gene pool" (p. 144).

"Boxes" around certain passages in the text are a welcome device. These contain condensed arguments, often statistical, or explanations of points which may be too intricate to interest most readers. Scattering the boxes through the text, with each located near the point of its first major application, seems better to suit the needs of many readers who might want to glance briefly at these topics than would such alternative devices as placing them in an appendix.

The references are mostly to recent work. Practical reasons for this are stated clearly in box 24 (p. 226). Yet one wonders why Lerner goes as far back as 1926 to credit the Russian zoologist, Chetverikov, with initiating the first experiments to test the hypothesis that considerable hereditary variability might be expected behind the uniform facade of interbreeding groups and yet does not mention F. B. Summer, who had already published so much work on the same phenomenon in the genus *Peromyscus*. Indeed, the classic paper by George H. Shull in 1908 was already entitled "The composition of a field of maize," and Shull himself referred to others who had stated similar ideas earlier. Priority is not ordinarily important, but if positive statements about it are to be made, their accuracy does assume some importance.

The difference between natural and artificial selection seems emphasized more than is justified. In either case, some genotypes leave more offspring than others. The difference is only in what causes those differences in reproductive rates. Differences in the causes may seem important to a philosopher interested primarily in *man's* relation to nature. Presumably, Lerner had this in mind when he emphasized that "natural selection has no purpose," but "artificial selection in contrast is a purposeful process." But if a mouse or a sheep were philosophizing about the matter, what becomes of that distinction? Man and his actions are to them only a part of nature. If the density of the human population increases or decreases in a given locality, with attendant changes in the opportunities for various kinds of mice or sheep to thrive, how does that differ to the mouse or sheep from the effects of an increase or decrease in the numbers of some wild predator or symbiont? And if man changes his opinion as to what kind of sheep he prefers, how is that qualitatively any different, to the sheep, from a change in the tastes or habits of some other predator or from some change in the climate, such as coldness and wetness, which might favor a sheep with long and coarse wool and open fleece over one with a tight fleece and fine wool?

Pages 176 to 196 suggest vividly how many things are and probably must be omitted from statistical models of a biological population, if those models are to remain simple enough to be amenable to statistical treatment at all. This is no new idea. Long ago, Karl Pearson said: "In dealing with any natural phenomenon—especially one of a vital nature, with all the complexity of living organisms in type and habit—the mathematician has to simplify the conditions until they reach the attenuated character which lies within the power of his analysis." Such statistical solutions of breeding problems as selection indexes, predictions of rate of improvement by this or that method of selection, estimates of heritability, etc., are only first, or at most second or third, approximations to describing biological situations which are so infinitely complex that they never can be described entirely. Some of us think these approximations are good enough to base our practical operations rather confidently on them. Others think that the approximations are so crude that the results of acting on them are almost as likely to surprise us as to be somewhat as expected. Probably both situations prevail, although with uncertain relative frequency. The philosophically minded may worry about that, but the practical plant and animal

breeder is likely only to ask for still better guides than these statistically derived concepts or estimates of parameters, for helping him to choose between the numerous breeding plans possible. The imperfections of a guide are regrettable, but if no more reliable guide has yet been found, what else would one use? Of course, third and fourth approximations would be welcome if they are appreciably more accurate, but many decisions in the real world simply will not wait until more experiments have yielded more accurate estimates of the genetic parameters in the real population which is at the breeder's command. He must decide now on the basis of what he knows now—and repent later, if need be!

The difficulties of describing a whole in terms of its parts, already familiar to every biologist who considers individuals as units, is extended (p. 204) to the description of populations. The difficulty is not peculiar to living organisms, since it is encountered, perhaps to a lesser degree, in such far simpler machines as watches and automobiles. In Learner's words, "gene-environment interaction, genetic correlation between traits, and non-additivity of gene action are abstractions. Statistically speaking, an organism or a population may be described in terms of one or another of these properties. But in a fundamental way they refer to a single entity, the genetic system. Division of the total into component features or descriptions of it in these terms is only a matter of convenience to the observer and the experimenter." Individuals are not mere mosaics of properties but are wholes, with some properties that arise out of the joint effects or interrelations of those parts and which cannot be divided among or prorated to those parts. Each individual is literally indivisible, but Lerner's meaning becomes at least a little vague when he concludes: "In the same way, the different aspects of a population, which may be treated separately from each other for purposes of analysis, are biologically inextricable from the whole organization of the interbreeding group or gene pool!"

Prophecies about the useful lifetime of a book are notoriously inaccurate, but one ventures to think that 10 years and perhaps more than 20 years from now *The Genetic Basis of Selection* will still be an essential work for all who want to scrutinize selection more carefully than is done in an introductory courses in genetics. It stands about midway between the usual subject-matter of genetics and the practical needs of animal and plant breeders. It should also be welcomed by students of evolution who want to take another hard look at whether selection will or will not make such changes as Darwin thought and as his successors argued pro and con.

REVIEWS AND BRIEF NOTICES

General Biology: Philosophy and Education 223
Biology: History and Biography 224
Ecology and Natural History 227
Evolution 229
Genetics and Cytology 230
General and Systematic Botany 231
Plant Physiology 234
Economic Botany 234
General and Systematic Zoology 235
Economic Zoology 237
Animal Growth and Development 238
Animal Morphology 240
Animal Physiology 242
Biophysics and General Physiology 245
Biochemistry 248
Microbiology 250
Health and Disease 252
Psychology and Animal Behavior 254
Human Biology 260

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

ATOMIC PHYSICS AND HUMAN KNOWLEDGE.
By Niels Bohr. John Wiley & Sons, New York; Chapman & Hall, London. $3.95. viii + 101 pp.; ill. 1958.

In this collection of seven brief addresses and essays, dating from 1933 to 1955, there is much repetition. Yet that very reiteration of the same thoughts, that re-emphasis of the same philosophical concepts, serves to show how persistently over the years one of the great minds of our times has concerned itself with the problem of human knowledge and the restrictions of scientific interpretations of nature.

Out of the impossibility of denying either the wave picture of light or the quantum view, and out of the impossibility of translating one into the other, Niels Bohr early arrived at his theory of complementarity. The wave concept and the quantum concept are not mutually exclusive, since they develop out of mutually exclusive experimental arrangements. A completely causal account of light phenomena just cannot be attained; we can only deal with the wholeness of light in a statistical manner. Probability, not finality, was thus shown to govern scientific knowledge.

Complementarity is similarly conceived to hold in the phenomena of living systems. This view does not at all mean that by refining our biological analysis to

the level of the quantum we can make a place in the causal mechanical analysis of science for the human will or the nature of life itself. Rather, says Bohr, it is probable that "the minimal freedom we must allow the organism will be just large enough to permit it, so to say, to hide its ultimate secrets from us," as the electron refuses to reveal at once both its position and its velocity. There is a point where we can no longer "distinguish sharply between the behavior of objects and the means of observation." It would follow that the freedom of the will is to be considered an aspect of conscious life which not only evades a causal mechanical description "but resists even a physical analysis fine enough for an unambiguous application of the statistical laws of atomic mechanics." On this view, mechanism and vitalism are equally irrelevant. The subjective and the objective are equally real, complementary, untranslatable aspects of phenomena. Information is complementary to other information about the same object when it is gained by some experimental arrangement that excludes the fulfilment of the conditions for the first approach. The use of concepts is complementary to the display of inherited instincts. Even different human cultures may be said to be complementary to one another, in that they characterize experience in terms of different frames of reference, "obtained by different experimental arrangements and visualizable only by mutually exclusive ideas."

The essays of twenty years after continue to develop the same theme. The "modern development of science has . . . created a new basis for the use of such words as knowledge and belief." In arriving at the inherent limitations in the notion of causality, science has itself found mechanistic and finalistic attitudes not contradictory, but complementary. One might say: there is nature, and there is the observer —object and subject. But the observer is himself a part of nature, a living organism that has evolved to a particular, limited, adaptive state of knowledge of nature; and he is actor on the scene of existence as well as spectator. He can observe only by modifying and being modified. What he *knows* is the change produced in him by the change outside of him: as Schrödinger illustrates it, the yellow color and the impact of light quanta of a certain frequency and wave-length—complementary, non-equivalent aspects of our total conception of light.

Among all scientists, biologists are strangely the most disinclined nowadays to consider epistemology, the most inclined to accept without question a causal mechanistic interpretation of nature. They need to ponder these ideas about the nature of scientific knowledge set forth by Niels Bohr, whether they are willing to accept them or not.

BENTLEY GLASS

BIOLOGY: HISTORY AND BIOGRAPHY

MEN AND MOMENTS IN THE HISTORY OF SCIENCE. *Edited by Herbert M. Evans. University of Washington Press, Seattle.* $4.50. viii + 226 pp.; ill. 1959.

These essays were originally presented at a History of Science Dinner Club. Either they were severely selected or the standards of the club are high, because every essay is excellent. The essays are: Ontogenetic and other developmental parallels to the history of science (E. Brunswik); J. B. Stallo and the critique of classical physics (S. Drake); Charles Fuller Baker, entomologist, botanist, teacher, 1872–1927 (E. O. Essig); On the history of science and of the second law of thermodynamics (F. O. Koenig); Planck's philosophy of science (V. F. Lenzen); The development of ethnography as a science (R. H. Lowie); Main topics in Marco Polo's description of the world (L. Olschki); Hypotheses non fingo (E. W. Strong); The first stellar parallax determination (O. Struve). It will be seen that the range of subjects is wide, so that every reader will probably find something of particular interest. I was myself particularly intrigued by the sketch of J. B. Stallo. Stallo's recently republished *Concepts and Theories of Modern Physics* is an important book which played a considerable role in the development of Henry Adams' ideas about science. Struve's article about the determination of stellar parallax brilliantly conveys the sense of intellectual adventure which was associated with this final proof of the Copernican theory.

PAUL F. CRANEFIELD

THE HISTORICAL DEVELOPMENT OF PHYSIOLOGICAL THOUGHT. *Edited by C. McC. Brooks and P. F. Cranefield. The Hafner Publishing Company, New York.* $6.00. xiv + 401 pp.; ill. 1959.

Most of the papers in this book were presented at a symposium commemorating the 100th anniversary of the Medical School of the State University of New York. The editors, in their introduction, state that the original purpose of the symposium was to direct attention to how knowledge is obtained, and in particular, how the researchers in the basic medical sciences acquire the concepts and intellectual procedures that are now common, and, indeed, automatic. When it developed that this purpose was too broad to be worked out adequately in a single symposium, the editors narrowed it down to a consideration of the development of those physiological concepts which are important in the current understanding of the function of the biological system.

In the opinion of the editors, the treatment of certain subjects at the symposium was not such as to produce a well-rounded book, and several supplementary papers were written and included. Hence the book possesses a certain overall unity in spite of having 17 authors.

The 5 sections into which the book is divided are somewhat unequal in length and content. Section 1: Medical and Basic Scientific Thought, contains only an article by O. Temkin dealing with the dependence of medicine on basic scientific thought.

Section 2: The Basic of Integrated Function of Human Behavior, has the following papers: Anatomical reasoning and physiological thought (L. G. Stevenson); Development of ideas on the synapse (J. Eccles); Historical reflections on the backgrounds of neurophysiology (J. F. Fulton); Development of ideas relating the mind with the brain (H. W. Magoun); The biology of consciousness (H. W. Smith); and The dynamic process in psychiatry (G. Zilboorg).

Section 3: Humoral Transport and Integrated Function, contains articles by C. D. Leake on The development of knowledge about the cardiovascular system: Discovery of the function of chemical mediators in the transmission of excitation and inhibition to effector tissues (C. McC. Brooks); Humorally-transported integrators of body function and the development of endocrinology (C. McC. Brooks and H. A. Levey.)

Section 4: Mechanistic Thought, Energetics, and Control Biology, has two chapters, The conservation of energy in the study of metabolism (G. Rosen); and Modern concepts in biological adaptation (L. von Bertalanffy).

Section 5: The Vital Process in the Diseased State, contains chapters by I. Goldston on The physiology and the recurrent problems of vitalism; What keeps men alive? (B. Kisch); The contribution of pharmadynamics and pharmacology to basic physiological thought (A. Gilman); and Towards a philosophical study of the idea of disease (L. J. Rathers).

There is also an introduction to each section and a general conclusion. Although all of the papers are excellent, two of them deserve special mention. Eccles has traced the historical development of the concept of the synapse in detail and has also outlined with remarkable clarity our present knowledge, and lack of knowledge, of the synapse both structurally and functionally. This particular paper will be of interest to all students of neurophysiology, whatever their level.

Gilman's discussion of the contribution of pharmacology to basic physiological thought is somewhat broader in scope, although its theme is simple: that pharmacology has often discovered the action of some drug empirically and this has pointed the way to some major advance in basic physiology. Most of his examples are chosen from the fields of chemotherapy and neurophysiology, and he describes them in a pleasant fashion.

The editors are to be congratulated on both the conception and the realization of the book, and one may hope that they can seize upon some occasion in the near future to have a similar symposium on some other facet of the medical sciences.

MYRON L. WOLBARSHT

A GUIDE TO THE HISTORY OF BACTERIOLOGY. *Chronica Botanica; an International Biological and Agricultural Series.*

By Thomas H. Grainger, Jr. The Ronald Press, New York. $4.50. xiv + 210 pp. 1958.

Despite its title, this book is in large part an annotated bibliography of the general literature of bacteriology, with some citations of historical interest included. The first section covers a wide miscellany of reference works, together with the principal periodicals. It is followed by a rather poorly organized subject bibliography. In special fields of bacteriology with which the reviewer is well acquainted, the citations furnish an incomplete and superficial guide to the historical development, with heavy emphasis on secondary sources. The final section covers biographical references. Some major figures are missing from the listed scientists; those omissions are probably attributable to the fact that obituary notices, frequently the sole published source of biographical information, were not systematically explored. There are numerous typographical errors (e.g., *Duclax* for *Duclaux*; *Circhow* for *Virchow*; *Bullock* for *Bulloch*; *Stainer* for *Stanier*).

If this neglected area of the history of science is eventually tackled seriously by the historians, the present work will be of little value to them. As a handy reference to major sources, it may be of some value to the working bacteriologist.

R. Y. STANIER

ALBERT JAN KLUYVER. HIS LIFE AND WORK. *Biographical Memoranda, Selected Papers, and Bibliography and Addenda.*

Edited by A. F. Kamp, J. W. M. La Rivière, and W. Verhoeven. North-Holland Publishing Company, Amsterdam; Interscience Publishers, New York. $11.00. xvi + 567 pp. + 1 pl.; text ill. 1959.

This memorial volume, which is excellently prepared and printed, begins with short articles about Kluyver. There is a brief biography, some appreciations by his pupils, and an evaluation of his contributions to microbiology and biochemistry. These

sketches, by various hands, occupy 165 pages and constitute an excellent biography of the man and his work. A bibliography of papers written by Kluyver or under his supervision adds greatly to the value of the biography. For the general reader this book is made most attractive by the inclusion of almost 400 pages of reprints of articles by Kluyver himself. Most of the articles are printed in English. Kluyver's style was good, and he was a very successful popularizer. Many biologists will remember with pleasure his book, written with C. B. van Niel, and entitled *The Microbe's Contribution to Biology*. Such readers will be glad to have available such papers as Unity and diversity in the metabolism of microorganisms; Life's fringes; Three decades of progress in microbiology; and Microbe and life. One important paper is not translated: Die Einheit in der Biochemie. It is written in clear and readable German and should be readily accessible to most American readers. This book is a distinctive and valuable contribution to the history of science and a superb tribute to Albert Jan Kluyver.

PAUL CRANEFIELD

HISTORY OF AMERICAN MEDICINE. *A Symposium. Edited by Félix Martí-Ibáñez. MD Publications, New York.* $4.00 (paper). viii + 181 pp. 1959.

Félix Martí-Ibáñez is well known as the Editor of MD magazine and as a participant in various activities relating to medical publication and publicity. The present volume consists of essays previously published in the *International Record of Medicine*, a journal edited by Martí-Ibáñez. The book is well prepared and printed and the prospective reader will no doubt wish to be informed of its contents, which are as follows: Introduction: The spirit of American medicine (F. Martí-Ibáñez); Guideposts in the history of American medicine (B. Spector); Medicine and medical practices among aboriginal American Indians (J. Duff); Diseases and medical practice in Colonial America (J. Blake); Medical education and medical schools in Colonial America (W. D. Postell); Medicine in the era of the American Revolution (W. F. Norwood); The lessons of the War between the States (C. R. Hall); The evaluation of American medical literature (N. Shaftel); The evolution of medical research in the United States (M. C. Leikind); A brief sketch of the rise of American medical societies (W. B. McDaniel, II); The nineteenth century American physician as a research scientist (Phyllis Richmond); Trends in American public health, from the Colonial Period to the present (G. Rosen); The contribution of Holland and Scotland to the evolution of medical education in America (D. Guthrie); American medicine in the world today: an historical perspective and reappraisal (R. Major). The articles have good bibliographies, and the book is indexed.

PAUL CRANEFIELD

MEDICINE AND SOCIETY IN AMERICA, 1660–1860. *By Richard Harrison Shryock. New York University Press, New York.* $4.00. x + 182 pp. 1960.

We are indebted to New York University for inviting R. H. Shryock to give the Anson G. Phelps Lectures on Early American History, since this invitation gave him an opportunity to review and summarize his long studies on the history of American medicine and to make them available in compendious form. The four chapters are entitled: Origins of a medical profession; Medical thought and practice: 1660–1820; Health and disease: 1660–1820; and Medicine and society in transition, 1820–1860. Shryock gives us an excellent picture of the medical theories and practices of the 17th and 18th centuries both in Europe and America, together with an indication of the content and theory of the often somewhat baffling medical systems of the time. As might be expected, the role of public health plays a large part in the book, as does the question "What was the role of medical science?" Medicine before 1860 is a somewhat depressing subject if one has any sympathy for the patients. I for one cannot agree that similarities between the systems of Rush and of Selye prove that Rush was scientifically inclined. What is suggested is rather that the demand for systems in medicine is insatiable.

Shryock outlines clearly the problem of the roots of scientific medicine in America. He has, of course, treated this subject elsewhere in a very satisfactory fashion, but the period from 1820 to 1880 seemingly deserves a most critical reexamination. There were good medical scientists in this country before the Johns Hopkins Medical School was founded: James Blake, W. A. Hammond, Charles Morgan, S. Weir Mitchell, C. E. Brown-Sequard, and Austin Flint, Jr., for example. Their failure to make medicine in America scientific may well be tied to the event Shryock mentions as a great disaster: the introduction of the London college hospital system into American medical education. Since hospital-oriented medicine is gaining in popularity today at the expense of university-oriented medicine, this question is one of great urgency. We are greatly indebted to Shryock for making these problems clear and for presenting us with a lucid picture of the setting of the stage.

PAUL CRANEFIELD

ECOLOGY AND NATURAL HISTORY

MANUAL OF VEGETATION ANALYSIS.

By Stanley A. Cain and G. M. de Oliveira Castro. Harper & Brothers, New York. $7.50. xx + 325 pp.; ill. 1959.

It is not always easy to describe adequately the vegetation of a given area, and the methods to be applied are not always simple or easily selected. It is still more difficult to describe the vegetation of a region not well known to the expected readers in such a way that they will be able to follow the author and see with his eyes all the remarkable plants and their communities. Most difficult, perhaps, is to describe the vegetation of a remote land in such a way that it is at once interesting and also elucidates and evaluates different methods of approach in an easily understandable, although scholarly way. This is, nonetheless, just what Cain and Castro have succeeded in doing in their new book which analyses the methods of vegetation study, taking the tropical rain forest of South America as an example.

Although the first part of the volume discusses different aspects of floristics, most of the book is devoted to the vegetation types and the community, and to different methods for their analysis. The details are too many to be mentioned, but one acquires information about the major characteristics of the rain forest before encountering discussions of different kinds of surveying and sampling for a more detailed description. Then there are chapters on abundance and density, frequency, coverage, size of sample units, combination of community characteristics, life form and leaf size, and many other phenomena of importance for a thorough understanding of the vegetation, with ample examples from the rain forest itself. These phenomena are studied in such a way that the reader not only gets a fairly distinct picture of the characteristics of the rain forest but also a clear idea of the importance and applicability of the methods discussed are applied.

The *Manual of Vegetation Analysis* does not intend to give a full coverage of all methods of study so far proposed and used in comparable investigations in different countries. Its conclusions as to the applicability of some of these methods may, also, be limited only to the tropical rain forest, though, in most cases, they are likely to be universal. The *Manual* is broad enough that it probably will very strongly affect vegetation analysis in many countries far from the tropical lands used as examples. Most of all, it combines learned exactness and educational generalizations in so masterly a way that it is likely to find worldwide use as a basic textbook of vegetation analysis and to gain the same classical importance as the text on the *Foundations of Plant Geography* written by Cain sixteen years ago.

ÁSKELL LÖVE

VEGETATION OF WISCONSIN. *An Ordination of Plant Communities.*

By John T. Curtis. The University of Wisconsin Press, Madison. $7.50. xii + 657 pp. + 50 pl.; text ill. 1959.

It has long been known that at the Plant Ecology Laboratory of the Department of Botany of the University of Wisconsin research work of unusual magnitude has been going on for many years, and that these studies have tried different approaches to investigate the past and present vegetation of Wisconsin and to describe it in detail. The present book is the result of these studies.

To describe the book in any detail would take several pages, since it embraces everything from remarks on the flora and its affinities to detailed explanations of differences between related communities. Large parts of the book describe and evaluate the different methods used; this evaluation is valuable for those who need to select the most effective methods for a study of similar problems elsewhere. It is likely that European plant sociologists who have obtained at least equally reliable results by aid of methods found inadequate in Wisconsin will look at the descriptions from a point of view different from that of the author. They need not be in doubt, however, as to the effectiveness of the Wisconsin school and the exactness of its descriptions within the limits of the methods used.

It is an easy task to praise a book of this quality, but it also ought to be simple to make criticisms. Some of the conclusions arrived at are not certain to be free from fallacy, and they are likely to be affected by the subjective opinions as well as the experience of the author. Yet it would hardly be fair to criticize Curtis for having enriched his science by making somewhat doubtful explanations that nevertheless represent a step forward. The author would very likely to be the first to admit that several weaknesses are particularly apparent in his discussions of the phytogeography of the area and the migration and history of its flora.

The drawings in the text are always informative and clear, whereas too many of the plates are far from satisfactory. This defect is a pity, since they could have added so much to the value of the book for persons who want to know more about the vegetation but are unable to visit the area itself. A simple comparison with similar pictures reproduced in the *Acta Phytogeographica Suecica* will document this

point, and the publishers of American books on ecological subjects could learn a great deal by leafing through one of the Swedish publications. In the *Acta*, pictures like Plates 25 and 26 would never have been accepted, to mention only two examples among many.

The author is not a taxonomist. This is evident from his nomenclature and his obvious indifference to the need for taxonomical exactness. He seems to be aware of some of the errors to be expected from this drawback. It is not certain that voucher specimens would have meant as much as he seems to think, although it must astonish every taxonomist to read that the author feels that an addition of about 90,000 sheets over a period of 20–25 years to a much too small herbarium would be too costly. One must wonder about the expenses for the ecological study itself during these years. There can be no doubt that the investigation would have gained by the use of Fernald's *Manual* (instead of that by Gleason) for just those groups the author feels Fernald has treated by "atomistic splitting." These are precisely some of the cases in which critical ecologists might use "minor variations" to discriminate between ecological conditions of considerable importance. This indifference to taxonomical exactness is quite the opposite of the spirit of European schools of plant ecology, in which the "splitting" has long been recognized as one of the best tools for exactness in the descriptions of plant associations. All the greatest plant sociologists of Europe would deserve the name "atomistic splitter" considerably more than the conservative Fernald did.

Curtis's book on the *Vegetation of Wisconsin* is no doubt the very best description available for any part of this continent. It will be a useful textbook for advanced students everywhere in North America. It is perhaps not as lucidly written as Tansley's *The British Islands and Their Vegetation*, but comes closest to it of all American ecological reviews. The greatest value of the Wisconsin book is that it is a pleasantly written manual covering the vegetation of a remarkable region, and that it has been composed by an energetic and wise author with wide knowledge and a keen eye for the vegetational beauties of the land where he lives.

ÁSKELL LÖVE

ANIMAL CAMOUFLAGE.

By Adolf Portmann. The University of Michigan Press, Ann Arbor. $4.50. 111 pp.; ill. 1959.

This beautiful, profusely illustrated little book is a readable, almost anecdotal, account of striking color patterns in animals; and may be considered an introduction to the subject. In a simple, straightforward fashion it describes some of the striking examples of coloration in nature and gives an elementary explanation of such underlying principles as disruptive coloration, countershading, and camouflage through masking, resemblance, and mimicry. It is especially adapted to the general reader and to pre-college students.

V. G. DETHIER

BUMBLEBEES.

By John B. Free and Colin G. Butler; two appendices by Ian H. H. Yarrow. The Macmillan Company, New York. $5.00. xiv + 208 pp. + 24 pl.; text ill. 1959.

Bumblebees have always appealed to students and observers of nature. In view of this, it is surprising that so few books dealing with these conspicuous insects have been presented to the public. This is the third authoritative book on the subject, the earliest being Sladen's *The Humble-bee* (1912); the other is Plath's *Bumblebees and Their Ways*. Only the last-mentioned deals with American species. The present volume will be of less interest to American readers because it deals with European species. It cannot be matched, however, for its fascinating and authoritative accounts of bumblebee behavior. A great deal of this information can be safely extended to American species. The photographic illustrations are exceptionally fine. The entire book is in keeping with the high standards which one has come to expect of the New Naturalist series.

V. G. DETHIER

COMPLETE FIELD GUIDE TO AMERICAN WILDLIFE. *East, Central and North.*

By Henry Hill Collins, Jr; illustrations by Russell Francis Peterson, Nina L. Williams, and John Cameron Yrizarry. Harper & Brothers, New York. $6.95. xx + 683 pp. + 48 pl.; text ill. 1959.

This handbook deserves the popularity it very likely will find. It certainly gives a great deal of value for the price, and fulfills to a satisfactory extent the need for a single field guide to "wildlife." All the information one could reasonably expect about the common vertebrate species is here. Almost every species is illustrated in color or black and white. These are adequate and extremely helpful pictures even though they are not really good, and in general do not approach in quality those in Peterson's field guides to the birds. A crude, but very useful map of the distribution in North America accompanies each species description. The textual description is organized as follows: common name; scientific name; code numbers (nowhere explained) to the one or more types of illustrations of that species; unique features, if any, that often permit immediate recognition; and a detailed description of size, color, habits, voice, eggs, immature individuals, sexual

differentiation, ecology, and much more appropriate information. Each class is introduced by a short survey of its characteristics as a whole and several references for more detailed information on the group. The thorough index includes common and scientific names. Every conceivable convenience is employed, down to a thumb guide to the major groups.

A possible error in judgement concerns the scope chosen by the authors. The tetrapods are covered in appropriate detail. Over 300 common fresh and salt water fish (including Chondrichthyes) are described, the marine forms being ones frequently found near shore. In addition to these, however, are much more limited descriptions of molluscs (only marine) and a skimpy assortment of other marine invertebrates. The 100 pages taken up by these could have been omitted with little loss. To include them seems foolsh, when the terrestrial and fresh-water invertebrates, which are so much more related to the life of the vertebrates described, have been omitted. Of course, the insects would necessarily have to be left to a separate volume to be described in any useful, comprehensive fashion.

One might qualify further. Of course the illustrations could be better, more information could be given, fewer mistakes made, and the cost reduced; but it is unlikely that anyone will soon succeed in bettering this book. Instead, let it be emphasized that here is *the* good, one-volume field guide, at least to the vertebrates, that so many have wanted.

DAVID R. EVANS

EVOLUTION

STORIA DELLA VITA SULLA TERRA. *L'evoluzione degli animali e delle piante. Attualità Scientifica, 5.* *By Emanuele Padoa. Feltrinelli Editore, Milano.* L. 3,500. 338 pp. + 11 pl.; text ill. 1959.

This book appears to be written for the general public, to commemorate the Darwinian centennial. The 20 chapters are grouped into three sections: (1) The Origin of Life; (2) Evolution of Vertebrates; and (3) Evolutionary Agents. In the first section the author reviews current theories of biochemical evolution, the evidences for organic evolution, and the geological record. The second section deals more fully with the paleontology and comparative anatomy of the vertebrate classes. The third treats of the internal and external mechanisms of evolution, includes genetics, and ends with a chapter on the doctrine of evolution and its value for philosophy.

The text is illustrated with tables and numerous line drawings, some borrowed from other texts. It is unfortunate that the author has seen fit to use once again that farcical series of implausible caricatures of vertebrate embryos (stemming from Romanes and purporting to demonstrate recapitulation) that has disfigured so many American textbooks. There are 11 mediocre photographic figures, largely of paleontological material. There is an index, but there is no table of contents.

D. RUDNICK

TAXONOMY AND GENETICS OF OENOTHERA. *Forty Years Study in the Cytology and Evolution of the Onagraceae. Monographiae Biologicae, Vol. VII.* *By R. Ruggles Gates. Uitgeverij Dr. W. Junk, Den Haag.* Dutch guilders 14.– 115 pp.; ill. 1958.

The title of this work, as well as the author's long and active participation in *Oenothera* research, lead one to expect a comprehensive review of the investigations of this genus which have extended well over half a century. Although the small volume brings together a surprising amount of information concerning the biology of *Oenothera*, its main portion is taxonomic and consists of a series of brief notes about the various species that the author recognizes. What criteria were used to select the specific comments included with each species is a matter not entirely clear. The taxonomic section also includes a discussion of variations observed within the numerous cultures of different geographical origin which were grown and analyzed to serve as a basis for the taxonomic conclusions. The study begins with an account of the evolution of both the genus and its family. A short review of the genetics and cytology of *Oenothera* concludes the volume.

The monograph is written with the assumption that the reader already possesses considerable familiarity with the *Oenothera* story. Its value would have been enhanced, especially for students, by the inclusion of a well-organized introduction to the major cytogenetic features of the genus. This would also have provided a framework in which many of the details mentioned throughout the book could have been more clearly interrelated. The many interesting facts and ideas are presented without real coherence and logical continuity.

Much of the work summarized herein was carried out in the late 1930's. It is unfortunate that such a long period has elapsed prior to the publication of this monograph. The extensive cytogenetic studies of natural populations, which have been carried on by Cleland and his associates during this same period, arouse one's curiosity regarding the cytogenetic characterization of the populations analyzed in Gates' studies. It is unfortunate that these two approaches lack closer correlation.

The book makes clear that the major evolutionary

patterns in this genus are reasonably well established. It also makes apparent that *Oenothera* provides an unusual opportunity for more detailed studies of the genecology and population dynamics of natural populations on which the major evolutionary developments in the genus are based.

ERICH STEINER

THE ORDOVICIAN TRILOBITE FAUNAS OF SOUTH SHROPSHIRE, 1. *Bull. Brit. Mus. (nat. Hist.) Geol., Vol. 4, No. 4.*

By W. T. Dean. The British Museum (Natural History), London. 30s. (paper). Pp. 73–143 + pl. 11–19; text ill. 1960.

GENETICS AND CYTOLOGY

MICROBIAL GENETICS. *Tenth Symposium of the Society for General Microbiology held at the Royal Institution, London, April 1960.*

Edited by W. Hayes and R. C. Clowes. Cambridge University Press, New York and London. $7.50. x + 300 pp. + 4 pl.; text ill. 1960.

While this volume will be of interest mainly to investigators in microbial genetics and allied areas, an introduction, written by B. A. D. Stocker, should facilitate an understanding of its contents by persons who are less intimately aware of the progress in microbial genetics. As is the case in recent symposia of this series, neither an index nor discussion by participants at the symposium is provided. The editors have aided the reader by inserting numerous cross-citations among the papers in the volume.

The first developments in genetics arose from inquiries into the existence and general nature of heredity and of biological evolution. Scarcely had genetics emerged as a branch of biology when cytologists posed questions which greatly influenced and guided its course of development. The influence of this discipline on genetical research continues to be profitable at all levels of genetic analysis. However, advances in biochemistry, physical chemistry, and protein chemistry, as well as in biophysical techniques, pose challenging questions at a new level —the level of molecular biology. Most provocative of new genetical thinking have been the Watson-Crick model of deoxyribonucleic acid structure and subsequent proposals concerning the mode of its replication and its heterocatalytic functioning, and of the recombination of such genetically potent macromolecules. At the outset, microbial genetics showed its usefulness by rapidly affording confirmations of a number of already "established" genetic principles, greatly clarifying and extending others, and reopening concern over a number. For example, the critical roles of nucleic acids in heredity have now been established through work with microorganisms, as pointed out at the symposium in papers by A. Gierer (Ribonucleic acid as genetic material of viruses) and H. Ephrussi-Taylor (Deoxyribonucleic acid). Also, in several articles, especially those of D. G. Catcheside and A. Garen, one finds samples of the current status of the gene-enzyme relationship, first conceived in work on higher organisms and developed further with microorganisms. Yet much of the work in microbial genetics has to date been of a pioneering type which, while exciting in its own right, has contributed relatively little to the main stream of basic genetical thought. Such work includes the development of new techniques of mutant isolation and recombinational analysis, the elucidation of the "natural history" of genetic transfer between bacteria (reviewed in the symposium by W. Hayes and R. C. Clowes), the structure of the bacterial nucleus and chromosome (discussed by Hayes and creatively summarized by E. Kellenberger). While contributions of entirely new genetic principles have been rare, one important recent concept developed in work with bacteria is discussed *in extenso* by F. Jacob and coworkers and for the first time in this symposium their concept of the episome is an extension of the concept of phage and prophage, first clearly elaborated by A. Lwoff. Episomes are genetic elements which "may exist in two alternative states, either as autonomous units, replicating independently of the bacterial chromosome, or as integrated units attached to the bacterial chromosome with which they replicate." A second criterion, which proposes that episomes are "not essential constituents of the cell," appears to be superfluous and misleading, since not only are chromosomal deletions of variously essential nature known in a wide variety of organisms, including bacteria, but there is no evidence available to decide whether all essential constituents of the cell are, indeed, truly "chromosomal" rather than "episomal."

Attention is heavily concentrated in the symposium upon bacterial genetics, to the unfortunate exclusion of other very important topics (for example, phage genetics). Even in the realm of bacterial genetics, exceptionally ripe areas of investigation were omitted from inclusion in the symposium (for example, chemical mutagenesis and problems relating to metabolic control, such as those dealing with permeases, repression, or feedback control). The closest one comes to the realm of gene function and metabolic control is a descussion of bacterial growth by O. Maaløe. Maaløe's article, brilliantly composed in its own right, does not touch upon the enumerated questions very extensively. The symposium contents are enough, however, to provide a glimpse of many important areas of microbial genetical research. Per-

usal of the contents also convinces one that microbial genetics is a long way from a solution of the many basic questions it has set out to answer: the precise structure of particular regions of nucleic acid molecules in relation to their genetic attributes, the means by which this genetic material guides the production of particular phenotypes mechanism(s) of crossing over, etc. Nevertheless, one gets the feeling that it is only a matter of time before microbial geneticists, along with their companions in the chemical and physical sciences, will provide answers to these basic questions.

PHILIP E. HARTMAN

INBORN ERRORS OF METABOLISM.
By David Yi-Yung Hsia. The Year Book Publishers, Chicago. $9.50. 358 pp.; ill. 1959.

Hereditary metabolic diseases are those in which a block in metabolism occurs as a result of a mutation of a single gene. This is usually manifested by an abnormality in or a deficiency of a protein (enzyme or otherwise).

In 1909, when Garrod published the first edition of *Inborn Errors of Metabolism*, the work was largely ignored because of the general ignorance at the time of enzymes and metabolism. Since then the number of inborn errors of metabolism has grown, by Hsia's count, to well over fifty. The present book, which unfortunately has the same title as that great classic work, is intended to make the present knowledge of human biochemical genetics available to the physician. In this role the book will undoubtedly succeed. The descriptions of the various ailments are good, and each disease has a section on clinical features, heredity, pathogenesis, diagnosis, and treatment, if any, and a short bibliography. In addition, there is an appendix that should prove invaluable since it outlines the various diagnostic tests for each hereditary defect discussed in the book. The book will also prove invaluable to the biochemists and geneticists generally, and to students entering this expanding field.

However, the discussion of gene action in the section General Considerations leaves much to be desired. First, it is improper categorically to describe a gene as "a submicroscopic *particle* of deoxyribose nucleic acid *and* proteins" (italics added). Secondly, it is probably very confusing to the reader to distinguish between the "products of the primary gene activity," which are the theoretical primary products, and "primary gene effects," which is what can be shown to be defective in the mutant by physical or chemical means. Obviously, as our knowledge increases, the two will merge, but better terminology would be preferable.

There is an even more basic defect in the discussion. No matter whether one or several genes are involved in the specificity of a single protein, from a clinical point of view this does not matter; a clinical loss of a protein can, in some cases, be due to any one of a number of genes which can act independently to cause the protein loss. This has obvious effects on pedigrees and will tend to obscure relatively simple situations. In spite of this defect, the book will undoubtedly be a stimulus in the field of human biochemical genetics, and should encourage physicians to look for and record new types of inborn errors of metabolism.

EDWARD GLASSMAN

THE HANDLING OF CHROMOSOMES. *Third Edition.*
By C. D. Darlington and L. F. La Cour. The Macmillan Company, New York. $5.75. 248 pp. + 24 pl.; text ill. 1960.

The third revised edition of *The Handling of Chromosomes* is a greatly enlarged edition and consequently even more valuable than the previous edition (1st ed., *Q. R. B.*, 18: 288. 1942). It includes almost all of the new techniques used to any appreciable extent at present, while retaining many which are not so often used but remain valuable for working with chromatin. The information contained is extensive, ranging from fixation and staining procedures to nucleic acid estimation and autoradiography. Simple treatments, for teaching purposes as well as elaborate research techniques, are present and easy to find in this volume. Teachers, researchers, or in fact anyone whose interests involve in any way "the handling of chromosomes," will find this book an invaluable addition to his library.

T. MERZ

GENERAL AND SYSTEMATIC BOTANY

THE TAXONOMY OF FLOWERING PLANTS.
By C. L. Porter; drawings by Evan L. Gillespie. W. H. Freeman and Company, San Francisco and London. $6.75. xii + 452 pp. + 1 pl.; text ill. 1959.

One of the best ways to induce an interest in taxonomic botany is to teach the student the subject by the aid of a handy textbook that requires the availability of living or herbarium material for study with each chapter. Such textbooks are not rare, though their quality is uneven, and it is often difficult for the non-taxonomist professor to choose among them. Although I for one would prefer to use together several recently published taxonomy textbooks, or at least use them in consecutive years, the new volume by Porter looks very promising as an

introductory textbook for students of plant taxonomy. It is arranged so that it can easily be the basis of a one-year course; even for a one-term course, it would be satisfactory. To say that it is interestingly written, however, would not be true, because the author has concentrated the text to such a degree that the student need not search for what facts he must learn: they are in every sentence of the book.

Although a substantial portion of the book is taken up by the two parts on the studies of selected groups of angiosperms, the first quarter is devoted to 9 chapters in which are described all the basic needs for acquiring skill in taxonomy. One concise chapter tells about the aims of taxonomy; another gives an historical summary of 19 pages; a third, which explains different kinds of taxonomic literature, is followed by a chapter on field and herbarium techniques, and others on nomenclature, concepts of taxa, the construction and use of keys, and phytography and terminology of description. The ninth chapter then discusses and explains the classification of monocotyledons and dicotyledons, as a kind of introduction to the main parts of the textbook itself.

Throughout the book the reader is sure to be impressed by the wide knowledge and liberal understanding of modern taxonomy that characterize the author. The selected bibliography following each chapter is probably compiled with the student and the availability of journals in mind, and not as a survey of the most pertinent treatises of taxonomic botany; but basic works in French and German are not omitted. It was, however, unwise (considering the numerous Canadian students who undoubtedly will use the text) not to include a reference to a single Canadian flora in the list of "major floras of North America north of Mexico." On the basis of the selection given, one could have listed the *Flore laurentienne* by Frère Marie-Victorin, the *Flora of Manitoba* by Scoggan, and the *Flora of the Canadian Arctic Archipelago* by Porsild. A fourth, the *Flora of Alberta*, by Moss, may have been published after the manuscript of the present work was completed.

In the main part of the book, the author keys out selected orders and families of monocotyledons and dicotyledons, describes the families, and relates something about their number of genera and species. Some examples of typical genera and, in some cases, species, are given and illustrated with a general picture, a floral diagram, and sometimes other necessary details. The selection is not easy; it must necessarily become arbitrary, being influenced by the interests of an author and his locale. Porter has succeeded admirably in avoiding the choice, as examples, of genera or species that are narrowly distributed in North America.

Although the descriptions and information in these chapters are generally exact and correct, they can be challenged in some cases, but never seriously. Thus, one may doubt even the approximate correctness of the number of species stated for several of the families, and even the number of genera is sometimes quite disputable. This admittedly depends upon what concepts of species and genera are followed, and is of questionable significance. The same is true regarding the selection of the names of orders and of some lower units. These are almost always correctly selected and correctly spelled. But in the grasses (one of the specialties of the author), he does not use the name *Triticeae*, which is correct for the wheatgrasses, but instead accepts the name *Hordeae*, a misspelling, since it ought to be *Hordeeae*, derived from *Horde-um* and the ending *-eae* for a tribe.

Very good drawings by E. L. Gillespie illustrate the book, but the reproductions of photographs are generally less satisfactory, and many could well have been left out. The identification of the species in the pictures is exact, as far as I can judge, although I doubt the correctness of the name *Urtica dioica* L. for Figs. 247 and 249. The plant in question seems to be one of the western races of the American relative of this species, since the truly Linnaean species has broader leaves.

In conclusion, it must be said that this textbook by Porter is a book of high quality and great merit. It can be recommended as an introductory textbook which can greatly increase the usefulness of any more comprehensive textbooks used in advanced courses in taxonomy.

ÁSKELL LÖVE

Sedum OF THE TRANS-MEXICAN BELT: *An Exposition of Taxonomic Methods.*

By Robert T. Clausen; drawings by Elfriede Abbe. Comstock Publishing Associates, a Division of Cornell University Press, Ithaca. $7.75. xii + 380 pp.; ill. 1959.

In Mexico a transverse zone of volcanism extends across the country from the vicinity of the Gulf of Mexico to the Pacific coast. This area lies between 18° and 22° N, but most of it is between 19° and 20° N. It contains great volcanic peaks, 7 of which are more than 4000 meters in altitude. The great environmental diversity and the disjunction of similar habitats on these peaks have resulted in the evolution of many species and races of plants, among which are more species of *Sedum* than occur in any other geographical area of North America. This is the group which the author has investigated, and the results obtained are described in the present book.

In the Introduction, the author emphasizes the importance of evolution as "the philosophical basis for a sound classification" and discusses genetical

matters in five of the ten propositions he gives as the philosophical basis of all the work on *Sedum*. These propositions are sound, though neither complete nor indisputable, and they seem to indicate that the author has little training in cytogenetical thinking, even though several recent textbooks on the subject have strongly affected his taxonomical ideas. The approaches to the problems later in the book are always those of a skilled and exact classical taxonomist with clear ideas as to the value of different methods of study. It is probable that biosystematical studies might affect the conclusions and explanations somewhat; they are not likely to alter greatly the taxonomical results, but could be expected in most cases to support them and strengthen them.

A whole chapter relates the history of the study of the genus *Sedum* in this area, and another chapter covers the geology in an interesting way. The bulk of the book, however, describes fully the morphological variation, distribution, and nomenclature of the 28 species native to the area and discusses their most likely pattern of evolution.

The book is a good review of the results so far obtained from the use of more or less classical methods for the study of this difficult genus; but if the author himself really believes that this is "an exposition of taxonomic methods" as claimed in the subtitle of the book, then he is taking taxonomic methods in a rather restricted way and must be ready to expect the criticism that only variations of the classical methods are expounded in his book. The experimental methods of modern biosystematics are nowhere evident.

The book is nicely printed on very good paper. The drawings are excellent and informative, and some of the photographs are of good quality. It is hoped that the book will constitue the first step in a thorough study of the evolution of this interesting material, and that later publications will give clear information on the evolutionary history of these plants based on cytogenetical experiments and other modern methods.

ÁSKELL LÖVE

TREES *of the Eastern and Central United States and Canada*.

By William M. Harlow. Dover Publications, New York. $1.35 (paper). xiv + 288 pp.; ill. 1959. Anybody interested in easy identification of most of the trees of Northeastern America will find in this little and inexpensive handbook a valuable aid in finding the names they want to know. Numerous pictures, together with handy keys and simple descriptions, guide the reader. In addition, perhaps half the text is filled with remarks on all possible matters connected with the trees in question, so that a reader will gain an interesting knowledge about many matters otherwise scattered all over the old and new literature about American trees. The first such comment is about the white pine, which according to "an early English writer," Josselin, is of interest to the ladies because "the distilled water of the green cones taketh away wrinkles in the face, being laid on with cloths." Another remark tells the story of the jack pine: "some of the early settlers thought that this pine was a witch tree and that it was dangerous to get nearer than 10 ft. from it." Still another repeats the old Greek saying "that poplar leaves were like women's tongues —never still." The reader will find that the text is enlivened by innumerable remarks of this kind.

As far as the descriptions go, the booklet is clear and correct and free from professional vocabulary not explained in the introductory chapter. The distributional information is, however, rather misleading in many cases, as to the United States and especially as to Canada. Since the latter country is mentioned in the name of the book, one finds it somewhat peculiar that many trees of southern Ontario and Quebec are mentioned in such a way that the reader will feel they are not met with in Canada at all. This is so for 5 species of hickory, 1 birch, the American chestnut, 7 oaks, the hackberry, the red mulberry, the cucumber tree, the tulip tree, and probably still others. Such mistakes are inexcusable in view of the fact that recent manuals by Fernald and Gleason could easily have been consulted to avoid them. It is also unnecessary to imply that the London plane is "a hybrid, presumably between the native sycamore and the Oriental plane," because there is no doubt that that is precisely its origin. In connection with the tulip tree, the author has undertaken to explain its survival and that of some other trees in eastern North America and not in Europe, as well as the reverse. His explanation, however, is geobotanically wrong. A forester ought to know that trees do not migrate like birds, but cease to form seeds if the climate deteriorates, and then die out. It would have been enough, in this connection, to state the facts but leave out the fallacious explanations.

There can be no doubt that the book is a very valuable source of information for the layman, and even the professional botanist can gain much assistance from it in the speedy identification of trees he has not seen before.

ÁSKELL LÖVE

MORPHOLOGICAL ASPECTS OF PARASITISM IN THE DWARF MISTLETOES (*Arceuthobium*). Univ. Calif. Publ. Bot., Vol. 30, No. 5.

By Job Kuijt. University of California Press, Los

Angeles and Berkeley. $2.00 (paper). iv + pp. 337–404 + pl. 34–48; text ill. 1960.

PLANT PHYSIOLOGY

MAGNESIUM. *The Fifth Major Plant Nutrient. By A. Jacob; translated from the German by Norman Walker. Staples Press Limited, London.* 40s. xii + 159 pp. + 8 pl.; text ill. 1958.

The author has brought together an extensive body of information concerning magnesium and its relationship to plants and the soil. The results of his own investigations, together with those of others, have been integrated to produce "the most comprehensive review of world literature on the subject yet published." The main theme of the monograph, the importance of magnesium in soil management practices, has been well served. The book should be of particular value to those in agriculture.

Walker has provided a very readable translation of the original book which was published in German in 1955. Unfortunately, the poor quality of some of the illustrations detracts from the presentation; fig. 2 is inverted; and no index has been provided.

The first chapters deal with the chemistry of magnesium, deficiency symptoms in tropical and temperate-zone crops, magnesium content in plants, its function in plants, and its importance to animals. The other 6 chapters discuss soil analysis, magnesium content in agricultural soils throughout the world, its economy in the soil, its interaction with other elements, magnesium-containing fertilizers, and fertilization experiments.

RICHARD D. DURBIN

ECONOMIC BOTANY

PLANT PATHOLOGY. *Problems and Progress, 1908–1958. Edited by C. S. Holton, G. W. Fischer, R. W. Fulton, Helen Hart, and S. E. A. McCallan. Published for The American Phytopathological Society by The University of Wisconsin Press, Madison.* $8.50. xx + 588 pp. + 50 pl.; text ill. 1959.

The American Phytopathological Society commemorated the fiftieth anniversary of its founding by sponsoring a series of symposia and major addresses at its 1958 anual meeting, held in conjunction with the American Institute of Biological Sciences. This book is a record of that meeting. In it are published the 7 major addresses delivered by plant pathologists, the papers presented in 9 symposia on various aspects of plant pathology, the introductions and epilogues pronounced by the symposium chairmen, and the remarks of others appointed to discuss the symposium papers. In all, 75 authors contributed to this volume. They, the American Phytopathological Society, the many APS Committees that planned the celebration and the publication, the editors, and the publisher, can be justly proud of the result.

Part I contains the major addresses made by seven of the Society's most distiguished members: E. C. Stakman, J. A. Stevenson, S. E. A. McCallan, J. C. Walker, G. L. McNew, J. G. Harrar, and J. G. Horsfall. These 7 papers are scholarly presentations of the historical and developmental aspects of plant pathology—thoughtful reflections on the past, analytical evaluations of the international and social aspects of this science, and intriguing looks to the future.

Parts II through X contain the symposium papers, including 4 on the physiology of parasitism, 7 on the genetic approach to parasitism and host resistance, 7 on fungicides, 6 on soil microbiology and root disease fungi, 4 on nematology, 8 on virology, and 5 on epidemiology. Also, the remarks of symposium chairmen and others are contained in 14 short articles.

The chapters vary somewhat in quality, but there is less of this than might be expected in a publication of this nature. In general, the basic information presented is sound, the conclusions valid, and the papers well written, very readable, and extremely interesting. Each reader will doubtless find interpretations or concepts with which he disagrees. Who would have it otherwise in a book concerned primarily with the advancing frontiers of a rapidly expanding science? The individual papers are uniformly thought-provoking and at times speculative. For these reasons, and also because not all phases of plant pathology are covered, this volume is not a textbook of plant pathology. Nevertheless, all plant pathologists, particularly those who will use it for supplemental reading and not as a textbook, will find it an invaluable reference providing broad coverage and maintaining a pleasing balance between a treatment of the past, an evaluation of our present fund of knowledge, and a look at the future. In addition, the book contains much that will interest every biologist, for the science of plant pathology is varied in its scope, embracing physiology, biochemistry, genetics, horticulture, agronomy, mycology, bacteriology, virology, and nematology. The information presented draws heavily on all of these disciplines and in turn makes significant contributions to each. The viewpoints and experiences delineated are truly international: 9 nations are represented among the authors, 21 of them being from nations other than the United States.

The present reviewer agrees with the editors that this Jubilee volume is indeed "... a monument to a

half century of progress in plant pathology, a monument that will serve also as a tool to enhance future progress in the field."

A. F. Ross

GENERAL AND SYSTEMATIC ZOOLOGY

TRAITÉ DE ZOOLOGIE. *Anatomie, Systématique, Biologie. Tome V. Annélides, Myzostomides, Sipunculiens, Echiuriens, Priapuliens, Endoproctes, Phoronidiens. (Premier Fascicule).*

Edited by Pierre-P. Grassé. Masson & Cie., Paris. 190.00 N.Fr. viii + 1115 pp. + 5 pl.; text ill. 1959.

Zoologists throughout the world will welcome another volume of this valuable treatise. As is usual in projects of this type, publication has lagged deplorably behind original intentions. Of the 17 projected volumes—actually 22, since Volume I consists of two fascicles, Volume IV also of two, Volume V of three and Volume XVII of two—12 volumes (counting fascicles as whole volumes) have appeared, and three more are said to be in press. The present volume comprises the "Embranchement des Annélides." Zoologists will be dumbfounded at what constitutes "annelids" to the French authorities: the classes Polychaeta, Oligochaeta, Hirudinea, Myzostomida, Sipunculiad, Echiurida, Priapulida, Entropocta (badly spelled Endoprocta), and Phoronida (!). The other lophophorates are to appear in Volume V, fascicle II, which is also a hodgepodge of groups.

An introductory chapter by P. de Beauchamp discusses the origin of segmentation, leaning somewhat to a schizocoel theory, and the composition of the phylum, nicely limiting itself to the accepted classes of annelids. A very extensive treatment is given to polychaetes by the well-known authority of this group, P. Fauvel. It is well illustrated by black and white figures and several colored plates. Archiannelida, by P. de Beauchamp, is properly regarded as a heterogeneous assemblage that should be distributed among other groups of annelids. Marcel Avel deals satisfactorily with the Oligochaeta, and H. Herant and P. P. Grassé with the Hirudinea. These two classes ought to be made subclasses under a class Clitellata; but at least one can commend the obliteration of the artificial group Chaetopoda. These chapters complete the annelids, properly speaking, and are followed by an account of annelidan embryology and ontogeny by, inevitably, C. Dawydoff. There is a brief consideration of fossil annelids by J. Roger.

The Myzostomida are treated by M. Prenant, who grants their annelidan nature without coming to a decision as to their exact systematic position. Sipunculida are handled by A. Tetry, who regards them as annelids and rejects the group Gephyrea. He concludes, however, that the Sipunculida branched off from the main line that leads to the Annelida and Mollusca. C. Dawydoff treats the Echiurida and, along with other informed zoologists, considers them most nearly allied to polychaetes. The chapter on Priapulida is also written by C. Dawydoff, who follows current opinion in ranging them among the aschelminths, and states that this idea originated with Hammersten. The Entoprocta are excellently treated by Paul Brien, with some valuable original figures. He supports the separation of the Entoprocta from the Ectoprocta. The concluding chapter, on the Phoronida, by C. Dawydoff and P. P. Grassé, is embellished with a beautiful colored plate of a colony of *Phoronis hippocrepia*. The treatment reaches no definite conclusion as to the systematic position of the group. There follows an addendum of some 30 pages, reviewing recent literature on the various groups.

As in previous volumes of the series, emphasis is placed on anatomy, embryology, and systematics, and little consideration is given to ecology and physiology.

L. H. Hyman

FREE-LIVING NEMATODES AND OTHER SMALL INVERTEBRATES OF PUGET SOUND BEACHES. *Univ. Wash. Publ., Vol. 19.*

By Wolfgang Wieser. University of Washington Press, Seattle. $4.00 (paper). x + 179 pp. + 46 pl. 1959.

Study of the minute and microscopic fauna of the intertidal zone has made great progress on European coasts under the leadership of A. Remane, but has been almost completely neglected in the United States. The present work is therefore a welcome introduction to this fauna, and one that should stimulate similar work in other localities. The study of the fauna of intertidal sand has revealed many interesting animals, representatives of entire new groups of Crustacea, remarkable gastrotrichs, and curious archiannelids. The present work deals mainly with free-living nematodes, a group on which Wieser is a specialist. There were found 106 species of nematodes, of which 76 are new, including two new genera. Taxonomic descriptions of these, illustrated by an abundance of clear drawings, make up most of the volume. There is some consideration of other groups, mainly crustaceans, and much ecological information. The volume closes with a bibliography and an index of scientific names.

L. H. Hyman

TICKS. *A Monograph of the Ixodoidea. Part V. On the Genera Dermacentor, Anocentor, Cosmiomma Boophilus and Margaropus.*

By Don R. Arthur. Cambridge University Press, New York and London. $11.50. xviii + 251 pp. + 4 pl.; text ill. 1960.

Many advances have been made in our knowledge of ticks and tick-borne diseases since the period 1908 to 1926, when the first four parts of the monumental *Ticks, A Monograph of the Ixodoidea* appeared. Nevertheless, this series remains indispensable to all interested in the study of ticks and their role in disease transmission. Part V now joins this distinguished series and it follows in the great tradition of the earlier parts. The author of Part V is to be commended for an authoritative, comprehensive, and critical survey of the vast literature on the genera *Dermacentor, Anocentor, Cosmiomma, Boophilus,* and *Margaropus.*

As in the other parts of the series, this work is an exhaustive taxonomic study of the species in the several genera; but the format, which differs in several respects, represents a distinct improvement over that of the earlier parts. Thus, in addition to the standard treatment of the synonymy, literature, iconography, and descriptions of each species, Don R. Arthur has included information, whenever available, on related species, distribution, biology, and relation to disease. The arrangement of the species of the genus *Dermacentor,* according to their distribution in the Americas, in Eurasia, and in Africa, is highly desirable, since it obviates the need to proceed through lengthy keys to reach the proper determination. The inclusion of an index is another innovation which will be especially appreciated by all who have struggled through the unindexed earlier parts in search of specific information. The value of this index is enhanced by indicating those species which are condemned, doubtful, or insufficiently described. Finally, as an added feature, a detailed treatment is presented of the external and internal morphology of the genus *Dermacentor.*

The keys to the males and females are excellent and offer more than one choice in most couplets. Those for the immature stage are satisfactory, but they will undoubtedly provide many problems except for tick specialists. The inclusion of a key to genera would have been desirable, especially for the benefit of students unfamiliar with ticks and for those who do not have a copy of Part II of this series. However, this is not a serious omission, since keys to genera of ticks are more or less readily available.

The synonymy that introduces each species is concise, informative, and current. The descriptions of the males and females are adequate; but those of the immature stages, especially the larval stage, are not sufficiently detailed to permit accurate identification. However, this is not the fault of the author; it only serves to point out the need for more study of the larval stage of all species of ticks. The four plates included in this work are reasonably good photographic reproductions of ticks, but other than indicating the pattern of the scutal ornamentation, they have little value. On the other hand, the text figures, 510 in number, are satisfactory and should be useful in the identification of species. However, in some of these drawings the lines are too heavily inked and tend to obscure the clarity of some of the finer structures. Also, it should be noted that fig. 69, a representation of coxae I-IV in *Dermacentor variabilis,* is inverted.

From the overall standpoint, Arthur has done a magnificant piece of work. The volume will fill a long-felt need of parasitologists, entomologists, acarologists, and others interested in ticks.

GEORGE ANASTOS

DIE LARVEN DER HYDRACHNELLAE, IHRE PARASITISCHE ENTWICKLUNG UND IHRE SYSTEMATIK. *Parasitologische Schriftenreihe. Heft 10.*

By Ingrid Sparing. Gustav Fischer Verlag, Jena. DM 13.85 (paper). iv + 168 pp.; ill. 1959.

The Hydrachnellae, or fresh-water mites, have been studied primarily in the adult stage. The highly colored, usually bright red, free-living imagoes comprise a spectacular component of the zooplankton of fresh-water lakes and ponds. Interest in these forms has spread to the many species that are less readily seen, so that most of the fresh-water habitats of the world have been searched in an effort to collect the so-called water mites. Some 3,000 species have been classified in 30-odd families. The larvae of water mites, on the other hand, have for the most part been ignored.

This volume deals with the larvae of water mites and is based on a comprehensive review of the previous literature and extensive personal observations in the field and laboratory. Keys to the families, genera, and species based on the larvae are given. They are of necessity very incomplete because so few of the larvae of water mites are known, but they are a good beginning on which future workers can build. In preparing the keys, the external anatomy of the larvae of the available species was studied from a comparative viewpoint. The setae on the body were named and numbered, so that valid comparisons could be made. The setae of the gnathosoma and appendages were also considered but in a somewhat superficial manner, so that valid comparisons are not as clear-cut.

In addition to morphological studies, an account of the life-cycles of water mites is given. The author recognizes four man types of larval behavior as follows: (1) parasites of water-dwelling insects; (2) parasites of sponges and mussels; (3) parasites of flying insects; (4) non-parasitic larvae. Of these types, those that are parasites of flying insects, such as mosquitoes, dragon-flies, crane-flies, and the like, are by far the

most common. The different types of larval behavior lead to different types of life cycles. Those species that are parasitic on water-dwelling insects usually overwinter on their hosts or as eggs. Those that parasitize sponges overwinter as adults. Species that live in mussels overwinter as adults and eggs. The parasites of flying insects overwinter as adults on nymphs, and the species whose larvae are non-parastic also overwinter as adults, nymphs, or in both stages.

As a result of comparative morphological, ecological, and developmental studies, the author concludes that the Hydrachnellae are a monophyletic group with the possible exception of one family, the Hydrovolziidae. While evidence in favor of this viewpoint is presented, it is my own opinion that much more detailed studies of the larvae of water mites must be made, so that they can be compared with the larvae of related terrestrial families in a more meaningful way.

In conclusion, it should be emphasized that this book is basic to future studies on the larvae of the Hydrachnellae. It is an essential for all serious students of the Acarina.

G. W. WHARTON

AËDES AEGYPTI (L.). THE YELLOW FEVER MOSQUITO. *Its Life History, Bionomics and Structure.*

By Sir Rickard Christophers. Cambridge University Press, New York and London. $14.50. xii + 739 pp.; ill. 1960.

In 1901 Christophers published an important paper on the antomy and physiology of the adult mosquito. From that time to the date of the publication of this book, Christophers has contributed 59 active years of work to the study of mosquitoes and mosquito-borne diseases. We are fortunate to have the benefit of his extensive knowledge and experience in the writing of this book on *Aedes aegypti*, which is perhaps the most important species of disease-transmitting insects. There are 31 chapters, most of them dealing with the morphology, histology, and certain aspects of physiology and biology of the egg, larva, pupa, and adult. There is one chapter on rearing and other techniques for the manipulation and study of mosquitoes.

Emphasis is placed on the mosquito's external and internal morphology and histology. The literature of these subjects is so scattered that it is useful to have available the detailed descriptions, based not only on published work but also on the author's unpublished observations presented here for the first time. One might note that there is disagreement between Christophers and Snodgrass in the interpretation of the homologies of some structures. Thus the anterior part of the alimentary canal within the head, which Snodgrass insists should be referred to as the cibarium, is in Christophers' opinion more correctly designated as the buccal cavity.

Morphological details include extensive tabulations of muscles and a minute description of the alimentary, respiratory, nervous, circulatory, and reproductive systems. The illustrations are clearly drawn, and reflect the care with which the anatomical observations were made.

Aedes aegypti, being a species that is readily colonized, has been subjected to more studies than any other mosquito. The literature is very extensive. Christophers has presented the various problems which have been studied, but many of these discussions are rather brief; and if one may advance a mild criticism, it is that a more thorough and critical review of the biology and physiology would be desirable, even at the expense of some of the morphological sections. An example is the dismissal of the recent work on the influence of blood and protein components upon ovarian development by a single sentence which only lists several references.

There are a few errors. Thus the word oocyst is used for oocyte (footnote, p. 493). Metcalf (1945) is said to have studied the physiology of the salivary glands of *A. maculipennis* rather than of *A. quadrimaculatus* (p. 492). It is implied that *A. aegypti* is a vector of Western and Eastern equine encephalitis in Africa, although these viruses actually occur in America, where *A. aegypti* is only an experimental vector (p. 82). Matheson and Hinman (1928) are quoted as concluding that solutes are not food for mosquito larvae (p. 260). The reference cited is in error, and in other papers these authors state clearly their conclusion that solutes are a source of food for mosquito larvae. It is also surprising to read (p. 470) that the occasional feeding of *A. aegypti* on corpses is of importance in the spread of yellow fever.

In spite of such mishaps, this book will be a most useful reference to workers in medical entomology.

L. E. ROZEBOOM

ECONOMIC ZOOLOGY

MARINE BORING AND FOULING ORGANISMS. *Friday Harbor Symposia.*

Edited by Dixy Lee Ray. University of Washington Press, Seattle. $8.50. xii + 542 pp.; ill. 1960.

The title of this volume may be misleading. It contains much more than a description of marine organisms which burrow into or otherwise damage wood. In September, 1957, a group of leading scientists from the United States and abroad gathered at the Friday Harbor Laboratories of the University of Washington to discuss "basic research approaches to

the problem of marine biological deterioration." It is fortunate that the proceedings of this symposium are available, for the papers presented are of interest in three distinct areas of endeavor. First, intensive attention is devoted to biological studies of the Limnoria (7 reviews), teredinians (4 reviews), and barnacles (4 reviews). The taxonomy and ecology, histology and cytology, and nutrition and physiology of these organisms are detailed, to make each of these sections a comprehensive study of the basic biology of a group of boring and fouling organisms. Second, an excellent section (11 reviews) deals with cellulases of various sources. Almost every aspect of enzymatic cellulose degradation is enumerated. This section alone is of such length and quality as to justify publication of the proceedings. Third, Economic Implications and Evaluation are discussed in a section (8 reviews) which includes papers on testing and evaluation procedures, wood treatment and preservation, mineral translocation, and the mineral content of woods. This treatise is recommended to all who are interested in any of these three areas of marine biological deterioration: the organisms, the enzymes, or the applications.

PAUL A. HARTMAN

ANIMAL GROWTH AND DEVELOPMENT

AN INTRODUCTION TO EMBRYOLOGY.
By B. I. Balinsky. W. B. Saunders Company, Philadelphia and London. $7.75. xi + 562 pp.; ill. 1960.

Many teachers of embryology have deplored the lack of a textbook which combines an adequate treatment of vertebrate developmental anatomy with an accurate and thorough modern presentation of analytical embryology. Balinsky's book should put an end to the majority of the complaints.

This book is written for undergraduates who are thoroughly trained in general zoology. While emphasis is placed upon vertebrate development, examples are chosen from all realms of the animal kingdom whenever pertinent. It is also assumed that the student is conversant with the fundamentals of genetics, cytology, and biochemistry. In the first sentence the author asserts: "The aim of this book is to make the student familiar with the basic facts and problems of the science of embryology." Facts and problems are interwoven throughout the succeeding 516 pages of textual material in a manner which unmistakably brands the author as a competent critic of this branch of biology.

The book begins with a quick presentation of the compass of embryology, followed by a preview of the phases of ontogenetic development, and then presents a condensed history of the main trends of embryological thought. Gametogenesis is dealt with in a most unusual manner: the account of meiosis is sharply curtailed—for after all, hasn't the student studied this in his introductory biology course? Instead, chemical morphology and the biochemical changes associated with gametogenesis are emphasized. The account of fertilization is up to date through 1957 and includes the studies of J. C. Dan and Wada, the Colwins, Rothschild, Metz, and others. Cleavage is dealt with in a neatly comparative way (for five phyla). It is a pleasure to find the blastocoel in discoidal blastulae accurately represented for once. Here are treated localization and segregation, nuclear differentiation (through Briggs and King, 1957), egg organization, and the action of maternal (or pre-maturation) genes in early development.

The presentation of gastrulation is superb. Archenterons are not invented where they do not exist. The material is accurate, up to date, comparative (among chordates), and detailed, and appropriately includes a treatment of tissue and cell affinities and even of metabolism during gastrulation. There follows a chapter, on the determination of the primary organ rudiments, which outlines the techniques of experimental morphology and introduces the concepts of prospective fate and potency, progressive determination (autonomous and dependent), induction, competence, and regional specificity. This chapter concludes with an exhaustive analysis of the nature of neural induction and related questions, unhappily marred by two non sequiturs of interpretation at the top of p. 175. The documentation is impressive, including, as it does, some 80 literature citations.

Chapters on embryonic adaptations and on genetic factors during gastrulation are both very good. Organogenesis is introduced by outlining the types of morphogenetic processes which occur, including a brief discussion of the causative cell-intrinsic and extrinsic factors involved. Then the development of organs is presented, germ layer by germ layer, with strong emphasis in each instance upon the experimental analysis of causative factors. The genetic control of organogenesis is accorded a separate chapter.

A chapter on differentiation includes a presentation of chemical and immunological methods for the study of differentiation; a discussion of the stability of cellular differentiation that incorporates the results of experiments with cultured tissues and with dissociated cells, including the work of Moscona and of Weiss and Andres; and a description of selected achievements to date in the analysis of the chemical control of differentiation, including the work of Grobstein, Weiss and James—Fell and Mellanby are the victims of an oversight—and Hardy.

Growth is analyzed from the subcellular to the or-

ganismal level, appropriate cognizance being taken of the DNA-RNA-protein trinity. A separate chapter on correlative growth and differentiation presents examples of neural, mechanical, and hormonal mediation of correlative developmental responses. Here, as before, gene effects are treated separately in a chapter on the genetic control of growth and differentiation.

A chapter on metamorphosis deals in detail with this process and its mediation in amphibians and insects. A meritorious chapter on regeneration is comparative in treatment; but many American students of invertebrate regeneration will not subscribe to the general emphasis placed upon "I-cells" or "neoblasts" —undifferentiated regenerative cells—as the source of cells for regeneration, especially in coelenterates. The final chapter discusses asexual reproduction and its relation to regeneration, and compares it with embryogenesis.

The illustrations are good throughout, being taken largely from published primary sources; and the style is direct and effective.

While the book is in almost all respects a truly superior volume, a few points detract somewhat from the reader's general euphoria. The most striking of these is the combined treatment of von Baer's Law and Haeckel's Biogenetic Law. The author reinterprets von Bear's dictum, which is only accurate in general, as meaning that "features of ancient origin develop early in ontogeny; features of newer origin develop late. Hence the ontogenetic development presents the various features of the animal's organization in the same sequence as they evolved during phylogenetic development. Ontogeny is a recapitulation of phylogeny. The repetition is obviously not a complete one. . . ." Many objections could of course be voiced to this. I would prefer the viewpoint that since genes begin their detectable function at different periods in development, the later in development one observes related embryos the more "new" genes will have had their effects and the more divergent the embryos will appear. However, there is nothing to prevent the early action of a "new" gene. In fact, how else would one interpret the very large differences between a mammalian blastocyst, an avian blastoderm, and an amphibian blastula?

Terminology is in a few places unorthodox or inappropriate. The use of the term "blastoderm" for the tissue of a coelublastula like that of a frog is unorthodox, and reference to the nucleus as a "substance" connected with the growth of cells is inappropriate. The name "potassium hydroxide" would also seem preferable to "caustic potash."

The reservations that one might hold regarding small sections of the text are insignificant, however, when held up to comparison with the light which emanates from the greatest part of it. Balinsky has presented, to a mature college audience, modern embryology as viewed by a competent investigator. Indexed references (some 600) support all of his major contentions. Furthermore, no separation whatever is made between developmental anatomy and the experimental analysis of development. Rather, when the time comes to present organogenesis, the causative factors governing organ development are woven naturally into the presentation.

An Introduction to Embryology will probably serve to introduce college students to "the facts and problems of the science of embryology" for a number of years to come.

MALCOLM S. STEINBERG

CELL, ORGANISM AND MILIEU. *The Seventeenth Symposium of The Society for the Study of Development and Growth.*

Edited by Dorothea Rudnick. The Ronald Press Company, New York. $8.00. vi + 326 pp.; ill. 1959.

The subjects treated at the 17th annual symposium of the Society for the Study of Development and Growth concern aspects of growth and differentiation in a variety of animals and plants. A semblance of unity and coherence is attained by emphasis upon two aspects of developmental physiology. The devolopmental significance of some papers is not immediately obvious.

A thread of common interest that pervades several papers is the subject of muscle cells. These papers include a striking report of myoblast differentiation in tissue culture by Wilde, who uses both mouse and chick cells to observe cell "fusion." Hoffman-Berling considers the nature of general movement and contractility in non-muscular cells, and compares them with more highly specialized and organized muscle tissues. Nason and Vasington examine a possible role of tocopherol in muscle function, and Csapo reviews the effects of biochemical and endocrine interactions on the smooth muscle of the uterus.

Another thread linking several of the reports is that of the developmental significance of small molecules, such as CO_2, vitamins, substrates, hormones, in the cellular environment (whence derives the "Milieu" of the title of the volume). Moog gives an interesting account and interpretation of how cortisone, ACTH, and substrates influence the development of phosphatases in the chick embryo. Plant growth factors are considered by Luckwill and Torrey. The hormones involved in insect development are reviewed by Schneiderman and Gilbert; included are some recent findings on the presence of substances with juvenile hormone activity in a wide variety of organisms. A physiologically and biochemically oriented study of the interactions of the blastocyst and its uterine environment is presented by Lutwak-Mann.

The majority of the papers are of the usual high standards set by previous symposium volumes. There are only minor weak spots, difficult to avoid when so many authors contribute. On the whole the papers are stimulating and provocative. The title of the book, however, is still as general and undescriptive of the contents as were the titles of earlier volumes in the series. Such titles of volumes could well be eliminated, and the symposia might then be published under a general title so as to be more readily recognizable as collections of outstanding papers in developmental biology. This is what they are.

HANS LAUFER

NEUE BEITRÄGE ZUR ENTWICKLUNGSMECHANIK DER NEMATODEN. *Zoologica, Stuttgart. Heft 107.*

By Otto zur Strassen. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. DM 132.– (paper). vi + 146 pp. + 14 pl.; text ill. 1959.

Little has been done on nematode development since the classical studies of Boveri, who used *Parascaris equorum* (= *Ascaris megalocephala*). The present work is based on *Bradynema rigidum*, a small oxyuroid nematode found in the body cavity of the dung beetle, *Aphodius fimetarius*. An elaborate account is given of its cleavage, illustrated by numerous plates of figures and constantly compared with similar stages of other species. This is followed by a long analytical part, dealing with axes, asymmetries, polarity, and similar questions. It is concluded that the early development of nematodes is strictly of the mosaic type, brought about by the distribution through cleavage of determining particles, which come into existence stepwise and are spatially arranged through interaction with the micellar or molecular ground structure of the egg.

L. H. HYMAN

DEVELOPMENTAL ABNORMALITIES OF THE EYE. *Second Edition.*

By Ida Mann; foreword by Sir John H. Parsons; introduction by Conrad Behrens. J. B. Lippincott, Philadelphia and Montreal. $15.00. xi + 419 pp. + 38 pl.; text ill. 1957.

In the Introduction, Conrad Behrens, an eminent ophthalmologist in New York City, makes the following statement: "Everything that Sir John Parsons has said in praise of the first edition of this book is equally applicable to the second edition." This statement was a masterful way of stating that the second edition is merely a reprint of the first. That fact may reflect Miss Mann's opinion that relatively little has been contributed to the knowledge of developmental abnormalities since her first edition and that her text was at a stage of perfection which could not be improved upon. In support of this view no preface or foreword to the second editions exists to express just what justifies its appearance. No new illustrations are to be found, but slight changes in the text indicate that the author has reread certain passages and approves of the present treatment of the topics.

It is unlikely that we will find anyone who can write a smoother, more lucid text than Miss Mann. Certainly, not on the developmental aspects of the eye, for her knowledge probably exceeds that of any other living specialist on the subject. Nevertheless, the treatment must be considered a series of loosely related topics, arranged in anatomical sequence, and given with varying detail and completeness. Many of the conditions discussed are exceedingly rare, but are treated extensively; others that are exceedingly common are treated but briefly. This undoubtedly reflects the fact that knowledge in such briefly treated sections is very scanty, but surely it is possible to express in greater detail the development in some situations despite their rarity. Outstanding chapters, such as that on the iris and the fundus, are required reading for all specialists on the eye. It is necessary to emphasize the importance of such a text as this to the understanding and recognition of those ocular abnormalities that have a developmental genesis. The relevance of the book to current situations is timeless.

HENRY G. WAGNER

REPRODUCTIVE PHYSIOLOGY AND PROTEIN NUTRITION. *The Fifteenth Annual Protein Conference of the Bureau of Biological Research held on January 23 and 24, 1959.*

Edited by James H. Leatham. Rutgers University Press, New Brunswick. $2.00 (paper). x + 65 pp.; ill. 1959.

ANIMAL MORPHOLOGY

NOTIONS DE CYTOLOGIE ET HISTOLOGIE.

By M. Chèvremont. Éditions Desoer, Liége. 1,300 FR.B. iv + 994 pp. + 10 pl.; text ill. 1957.

While this textbook of cytology and histology will have very little impact on the American student, since comparable books exist in the English language, it should find wide use in the French-speaking world. It is a thoroughly modern work, devoting the first 284 pages to cytology as seen through the eyes of a competent experimental cytologist. Information derived from the use of tissue culture, submicroscopic morphology, and cytochemical techniques is presented. The section on histology has been well written, and gives a better than average coverage of vertebrate histology. The volume is well illustrated with black and white figures as well as color plates.

It should be an excellent textbook for a course in general histology for biologists and medical students. The only major criticism of this book is its lack of references.

R. R. COWDEN

HISTOLOGICAL AND HISTOCHEMICAL TECHNICS.

By Harold A. Davenport. W. B. Saunders Company, Philadelphia and London. $7.00. xx + 401 pp.; ill. 1960.

Davenport has compiled an excellent source-book of histological and histochemical techniques. The first section deals with general principles of histological technique: fixing, embedding, sectioning, etc. In the second section, formulae and procedures of various histological methods are presented. Here, all of the routine histological methods are covered, as well as many of the special methods for nervous tissue and connective tissue. The third section is concerned with histochemical methods. Like all books dealing with this area, it is not completely up to date. The area is moving so rapidly, however, that a comprehensive coverage in book form is virtually impossible. With the exception of the nucleic acids, the coverage of established methods for the major classes of macromolecules and demonstrable inorganic substances is excellent, and the techniques themselves are presented in a manner that would allow a novice to approach them without misgivings. The omission of a systematic consideration of methods for nucleic acids, however, is a critcal one in the light of the biological importance of nucleic acids and the large body of technical information now available concerning their histochemical demonstration. In spite of this particular weakness, this book is probably the best of those presently available for use as a textbook in an undergraduate histological technique course designed to meet the most modern requirements of experimental biology.

R. R. COWDEN

HÄMATOLOGISCHER MORPHOLOGIE UND FUNKTION DER ZELLEN VON BLUT UND KNOCHENMARK *sowie Darstellung hämatologisch wichtiger Krankheitsbilder.*

By Horst Stobbe. Akademie-Verlag, Berlin. DM 68.– x + 304 pp.; ill. 1959.

This atlas, written in German, should be of interest to non-German readers chiefly because of its very good color photographs of stained preparations. Some of these, however, do lack clarity of detail. There are also very good black and white phase-contrast illustrations. A wide variety of diseases is covered with a rather unnecessary stress upon certain rare conditions, such as Di Guglielmo's syndrome and myelomas with which apparently the author has had considerable personal experience. Other more common conditions are given far too little emphasis—for example, the hemoglobinopathies, considering the rapid increase in the knowledge in this field. The normal cells of the bone marrow are amply illustrated. The phase-contrast technique is used on fresh specimens with especially good effect to illustrate the development of a fibrin network in the process of clotting and the motility of neutrophils, lymphocytes, and monocytes. The text closely follows the illustrations and is adequate, although not outstanding. There is a useful appendix that includes staining and counting methods and techniques for examining fresh specimens under phase contrast.

All in all, this is a useful book to have on the shelf of a hemotology laboratory.

LOUIS K. DIAMOND

THE ANATOMICAL LIFE OF THE MOSQUITO. *Smithson. misc. Coll., Vol. 139, No. 8, Publ. 4388.*

By R. E. Snodgrass. Smithsonian Institution, Washington. Free upon request (paper). iv + 87 pp.; ill. 1959.

The medical and economic importance of mosquitoes has stimulated a great many extensive and thorough studies on these insects, including those on morphology and taxonomy. With interpretations of structure presented by many alert, competent authors, and with terms borrowed from vertebrate anatomy, it was inevitable that there arose considerable confusion in terminology relating to mosquito morphology. Snodgrass has made another valuable contribution to insect morphology in this publication, not only by bringing together a concise description of the external and internal anatomy of the larval, pupal, and adult mosquito, but also by drawing upon his extensive knowledge of arthropod morphology to interpret the homologies of the various organs. As is true of his other publications, the descriptions are accompanied by line drawings which clearly illustrate anatomical details. There are 30 numbered figures, but in most of these there are several separate drawings.

There are also pertinent observations on certain aspects of mosquito biology and physiology, and on the changes that take place during metamorphosis. It is noted, for example, that the organs of the mature larva are in part larval and in part pupal. Thus in mosquitoes the juvenile hormone must have a selective action on those organs which are essential to larval life, while other structures are permitted to continue development.

This is a valuable reference work for all students of mosquitoes. It is highly desirable that standardization of anatomical and taxonomic terminology for the Culicidae be achieved by following that presented in this publication.

L. E. ROZEBOOM

ANIMAL PHYSIOLOGY

THE BIOLOGY OF MARINE ANIMALS.

By J. A. Colin Nicol. Interscience Publishers, New York. $14.00. xii + 707 pp.; ill. 1960.

Nowadays a zoologist who has not spent some time at a seashore station must consider his education or experience incomplete. One byproduct of this state is the formidable bulk of literature about the results of these sojourns that is now accumulating in the journals. Nicol assures us at the outset that his book is intended for the beginners, "these young men and women and for undergraduates specializing in marine zoology." Perhaps so, or perhaps the book grew in scope after this opening paragraph had been composed and yet was fondly retained. In any event, one's first impression is that this book is analogous to Prosser's, except that it has a single author. It is an attempt to summarize the literature of physiology as it pertains to marine organisms (including vertebrates). While the title contains the word *biology*, the work is organized according to physiological categories, with chapters on salts and ion balances, respiration, feeding mechanisms, sensory organs, and so on. As might be expected, the chapters dealing with luminescence, effectors, and the like, are especially detailed. "Biology" as such is considered in such chapters as those on associations, skeletons, shelters, and special defences, as well as in the chapter on feeding. Reproduction is nowhere considered as a special aspect of biology, and the word is absent from the index! Some passing mention is given to larval responses, but the whole complex of reproductive cycles in the sea, lunar periodicity (also absent from the index), and sex (except for a brief mention of parasitic castration) has been omitted. This omission of reproduction is also apparent in other physiologies, notably that of Prosser et al., and must have some relation to the difficulty of studying this process with kymographs and oscilloscopes. Gonads, obviously, do not fit well between electrodes.

Aside from this omission of the facts of life, the book is a rich lode of all sorts of information, and no marine biologist will want to be without it. Fortunately, the author did not follow another trait of physiologists, that of reducing references to an almost meaningless code. He gives the titles in full at the end of each chapter. Only two or three of the 15 chapters have less than a hundred references. German references are not numerous, and Russian citations are sparse. Nevertheless, the author has done a lot of reading and will save many of us vaulable time by virture of his concise summaries of the essential information. Although this is a long and closely packed book, it is not verbose. As a result, it will be most profitably read at comparatively short sittings. It should be especially useful as a resource textbook in physiology courses, for which it will supply details and specific examples to support the instructor's generalizations. The volume possesses an appendix on saline media and a 25-page index.

JOEL W. HEDGPETH

THE PHYSIOLOGY OF CRUSTACEA. *Metabolism and Growth. Volume I.*

Edited by Talbot H. Waterman. Academic Press, New York and London. $22.00. xviii + 670 pp.; ill. 1960.

First and foremost, it is necessary to distinguish this book from the other multiple-authored books that now flood the market. This one is a polished, thoroughly planned, and integrated textbook; it is comprehensive and yet rich in detail. Abundant footnotes call attention to other relevant sections of the book, to important, very recent papers, and to reviews of similar subjects in other groups. Waterman and F. A. Chase have written a well-conceived introductory chapter that surveys the taxonomy, phylogeny, morphology, development, and ecology of the class as a whole. Many will make use of this brief, intelligent refresher course. Every chapter has a summary and conclusions. References are given at the ends of chapters in spite of the repetition thus involved; and every reference contains full title and inclusive page numbers. An author index gives page numbers for the reference itself (in bold type) and for the place where it is cited (in other type); what is more, if the reference was cited by number alone, that number follows the page number in parenthesis. A complete systematic index includes not only the pages where a given species is mentioned, but also all pages where, say, members of the Brachyura are discussed. There is, in addition, an extensive subject index. These notes are made to indicate the quality, the integration, and the meticulous attention to detail that characterizes the whole volume.

The contributions to the volume are as follows: Respiration (H. P. Wolvekamp and Waterman); Biochemistry of pigments (T. W. Goodwin); Blood chemistry (M. Florkin); Circulation and heart function (D. M. Maynard); Feeding and nutrition (S. M. Marshall and A. P. Orr); Vitamins (L. R. Fisher); Digestion and metabolism (H. J. Vonk); Osmotic and ionic regulation (J. D. Robertson); Excretion (G. Parry); Terrestrial adaptations (E. B. Edney); Ecology and metabolism (M. Florkin); Sex determination (H. Charniaux-Cotton); Integument and exoskeleton (R. Dennell); Molting and its control (L. M. Passano); Relative growth (G. Teissier); and Autotomy and regeneration (D. E. Bliss).

Needless to say, some contributions are better than others, but the greatest deficiencies are in the subject matter itself. One could argue that some of the topics

have been so little studied that they might well have been omitted entirely or at least reduced to a few pages. Several might be considered in this light, but it would serve little purpose to single them out.

The second volume of the work promises to be of even wider interest than this first one, in that it will deal with sense organs, neuromuscular systems, and behavior; and it is here especially that Crustacea have best served the interests of general physiology as opposed to crustacean physiology for its own sake. Volume I, owing to its quality, should have as long a useful life as is possible for such a book in these times.

DAVID R. EVANS

THE LYMPHOCYTE AND LYMPHOCYTIC TISSUE. *International Academy of Pathology Monograph No. 1. Edited by John W. Rebuck. Paul H. Hoeber, New York.* $10.50. xiv + 312 pp.; ill. 1960.

This volume, the initial book in a series of Monographs in Pathology, contains the material from a course held by the International Academy of Pathology at its annual meeting in Boston in 1959. In the Foreword, Robert E. Stowell, the Academy's President, states as the aim of the series to "contribute to the development of the reference literature in the field of pathology." He adds, "Manuscripts selected for publication in this series will meet the highest standards of scientific authenticity and educational value." If *The Lymphocyte and Lymphocytic Tissue* is a fair sample of what is to come, then the pathologists, and indeed all of us, are fortunate, for the book treats fairly and reliably most aspects of a difficult and often controversial field. The 19 chapters, by 21 authors, fall logically into 4 groups: the origin of lymphocytes and the embryogenesis of lymphocytic tissue; the cytology of lymphocytes, including cytochemistry and electron microscopy; the physiological role of lymphocytes, embracing studies of their life span and turnover, inflammation, immune reactions (both antibody formation and homograft immunity), and effects of radiation; and finally, 9 chapters on lymphocytic diseases and disease mechanisms, occupying nearly fifty per cent of the book. Most of the book is well illustrated; the photomicrographs are, for the most part, excellent, in contrast to the electron micrographs, which are less satisfactory. Perhaps the greatest disappointment stems from the failure to illustrate William Bloom's article, The Embryogenesis of Lymphocytic Tissue. Seven of his proposed illustrations, not published here, have been published in color elsewhere; appropriate references are given. Seven other unpublished color photographs are described. The lack of illustrations reduces the value of this otherwise concise, useful presentation.

As might be expected of such a collection of articles, the chapters are uneven in quality. Among those which the reviewer found particularly clear and informative are Lymphocytic Response to Tissue Transplantation, by T. N. and Susanna Harris, and John Rebuck's Structure of the Lymphocyte Series of Cells in Relation to Disease.

References are provided for each chapter, and an excellent index is provided.

JAMES D. EBERT

INTERNATIONAL REVIEW OF NEUROBIOLOGY. *Volume I.*

Edited by Carl C. Pfeiffer and John R. Smythies. Academic Press, New York and London. $10.00. xii + 383 pp.; ill. 1959.

This book attempts to give an account of recent progress in neurobiological research. Its purpose is to cover the basic explanations of clinical and physiological phenomena by means of chemical and physical concepts and also to describe the development of new effective treatments of disease. Emphasis has been placed within basic sciences upon those discoveries which may in time be applied to cures for human diseases. Some nature of the coverage of the book can be gained by examining the table of contents and noting some of the articles: Recent studies of the rhinencephalon in relation to temporal lobe epilepsy and behavior disorders (W. R. Adey); Chemical agents of the nervous system (C. O. Hebb); Parasympathetic neurohumors, possible precursors and effect on behavior (E. C. Pfeiffer); Physiological and biochemical studies on schizophrenia with particular emphasis on mind-brain relationships (R. G. Heath); Studies on the role of ceruloplasmin in schizophrenia (S. Martens, S. Vallbo, and B. Melander); and Investigations in protein metabolism in nervous and mental diseases with special reference to the metabolism of amines (F. Georgi, C. G. Honnegger, D. Jordan, H. P. Rieder, and M. Rottenberg).

These papers are quite well done and certainly fulfill the purpose of the book adequately by presenting summaries of the recent progress in their respective fields. The two other papers in the book deserve special mention. The psychophysiology of vision (G. W. Granger) contains a remarkable discussion of the physiology of vision and its abnormalities caused by various psychological and physiological conditions. The problems of visual thresholds are discussed in detail with a clarity that justifies study by all serious students of the physiology of vision. The other paper is on the nature of electrocortical potentials of synaptic organizations of the cerebral and cerebellar cortex (D. P. Purpura). This paper, the longest one in the book, is in itself sufficient justification for adding the book to one's library. I think it will be safe to say that no student of the electrophysiology of the brain should be un-

familiar with this chapter. It includes a discussion of whether the origin of brain waves is axonal, dendritic, cellular, or post-synaptic. A correlation is made between this discussion and the work on the standing surface potentials and their probable origin. It shows where inferences as to the cortical organization can be made and where they cannot be made. The most recent theories of neuronal activity are touched upon and their implications in cortical and cerebellar physiology are considered. A semi-historical approach is employed throughout, and the student is able to follow in logical sequence how the several theories have arisen and what the evidence for each one is.

One can only hope that future volumes in this series will be on the same high level as the present one. The series will then indeed be one of the most outstanding reviews of its type.

MYRON L. WOLBARSHT

METABOLIC ASPECTS OF RENAL FUNCTION.

By William D. Lotspeich. Charles C Thomas, Springfield. $7.50. xiv + 214 pp.; ill. 1959.

This book, a thoughtful and challenging commentary on significant, present-day approaches to various problems of renal biochemistry and function, can be heartily recommended. The volume grew out of a series of lectures presented at the Mount Desert Island Biological Laboratory in the summer of 1958. Not intended as a comprehensive treatise, the book is a selected series of essays on themes of particular interest to the author. Lotspeich has placed in larger context much of the research with which he has been engaged over the last fifteen years. Areas that are surveyed include phosphate and amino acid transport, ammonia excretion, the mechanism of action of phlorizin, the relation between renal excretion and utilization of metabolic substrates, and the role of the tricarboxylic acid cycle in the kidney. The author states that, although he has not worked directly in the field of organic acid and bases, a chapter on these substances was included because "it is a fascinating trail of research, full of frustrations and brilliant strides, and in addition has never been brought together before in its consecutive development." Each chapter has a bibliography.

EVELYN HOWARD

THE FLUIDS OF PARENTERAL BODY CAVITIES.

By Paul D. Hoeprich and John R. Ward. Grune & Stratton, New York and London. $4.75. vi + 98 pp.; ill. 1959.

This very thin volume brings together previously scattered information regarding the fluids of the pleural, peritoneal, and pericardial cavities, as well as synovial and cerebrospinal fluids. It was written for "medical students of all ages and specialties." It appears to contain sound and useful information and has a bibliography. There are extensive sections on techniques of collecting the various fluids from patients. The section on cerebrospinal fluid includes the following, in a discussion of hazards to the patient: "A clear conception of what information is being sought is of prime importance. With a modicum of forethought, *before* lumbar puncture the operator will have collected all the necessary equipment, arranged for assistance (for positioning and perhaps, restraining the patient) and allocated time for prompt, thorough examination of the specimen." The diagram on p. 43 contains an arrow intended for the coracoid process which points unmistakably to the clavicle. Other infelicities are: the use of the word *equilibrium* rather than *steady state* (p. 2); *ionic harmony* rather than *electrostatic neutrality* (p. 5); and an apparent discrepancy between the text (p. 33) and the table (36) regarding the protein content of normal human synovial fluid. The manuscript was awarded a first prize in the first Modern Medical Monographs competition.

EVELYN HOWARD

MANOMETRIC TECHNQUES. *A Manual describing Methods Applicable to the Study of Tissue Metabolism.*

By W. W. Umbreit and 12 contributors. Burgess Publishing Company, Minneapolis. $6.50. IV + 338 pp.; ill. 1957.

The past editions of this book have proved to be among the best-thumbed laboratory manuals available; indeed, its influence on experiments in various laboratories throughout the world cannot be overestimated. The present edition should prove even more useful, since it includes a section on Colorimetry and Spectrophotometry and on chromatographic techniques, while all of the other sections have been brought up to date. However, it is likely that owners of the older editions might not find it worthwhile to purchase the new edition because of the high cost. Students, however, will find the book invaluable for the excellent description of methods pertaining not only to manometry but also to general techniques in the study of tissue metabolism.

EDWARD GLASSMAN

HEMATOPOIETIC MECHANISMS. *Ann. N. Y. Acad. Sci., Vol. 77, Art. 3.*

Edited by Walter S. Root with 65 other contributors. The New York Academy of Sciences, New York. $5.00 (paper). ii + pp. 409–820; ill. 1959.

This volume contains a series of papers presented at a conference in May, 1958. The subject matter of the papers is somewhat varied. There are 13

presentations relating to the nature of erythropoietin and to the site of manufacture of the stimulus to red cell formation. A number of papers deal with methods for labelling leukocytes, and conflicting data are presented regarding the life span of leukocytes. A number of other papers discuss tissue culture techniques, the leukocyte pool in the body, hemolytic mechanisms, and other biological phenomena related to hemopoieses. The volume contains a great deal of valuable data and presents a number of interesting conclusions regarding hemopoiesis and an equal number of challenging problems.

J. R. KREVANS

THE SENSE OF SMELL.

By Roy Bedichek. Doubleday and Company, Garden City. $3.95. 264 pp. 1960.

Bedichek, now deceased, was a naturalist who had notably broad interests and knowledge. His book is an enthusiastic course in "olfactory appreciation" that touches on everything to do with odor: folklore, literary references, newspaper reports, personal observations, and human attitudes, as well as some physiological information on insects, fish, and mammals. It is not a critical study of the subject, but many would find it provocative. For the person whose interest becomes aroused, the book provides an adequate bibliography. Pleasantly and easily, the reader learns about the fascinating uses to which olfactory organs have been put by animals; about man's neglect of his still powerful olfactory abilities, partly owing to his taboos; and about all the wonderful mysteries awaiting solution.

DAVID R. EVANS

THE HARVEY LECTURES. *Delivered under the Auspices of The Harvard Society of New York, 1958–1959, under the Patronage of the New York Academy of Medicine. Series LIV.*

By François Jacob and 8 other contributors. Academic Press, New York and London. xvi + 312 pp.; ill. 1960.

Series 54 of the Harvey Lectures contains papers presented in 1958 and 1959. As usual, no common theme unifies the several contributions other than that the authors are promising or already distinguished investigators in the currently active area of biological research. The articles in this volume are the following: Genetic control of viral functions (F. Jacob); Metamorphosis and body form (V. B. Wigglesworth); Methods of approach to the problems of behavior (K. Lorenz); Enzymatic synthesis of the purine nucleotides (J. M. Buchanan); Excretory function of the liver (S. E. Bradley); Metabolic studies with normal and malignant human cells in culture (H. Eagle); Excitation and inhibition in single nerve cells (S. W. Kuffler); Carotenoid pigments, problems of synthesis and function (R. Stanier); and Historical and current aspects of the problem of protein synthesis (P. C. Zamecnik).

DAVID R. EVANS

BIOPHYSICS AND GENERAL PHYSIOLOGY

BIOPHYSICAL SCIENCE. *A Study Program. Edited by J. L. Oncley, F. O. Schmitt, R. C. Williams, M. D. Rosenberg, and R. H. Bolt. John Wiley & Sons, New York.* $6.50. viii + 611 pp.; ill. 1959.

What is biophysics? There are almost as many answers to this question as there are people who call themselves biophysicists. Most of the 61 papers by the 41 authors of this book would be included on the basis of any definition of biophysics. Several of the papers, however, might be more appropriately assigned to some other field, such as physical biochemistry or histology. This is to quibble. Whatever biophysics is, and whether or not these papers are biophysical, are unimportant, in comparison to the fact that the individual papers are extremely well done and are obviously related to each other. It is impossible to describe in the space available all the papers in this volume, although they are almost without exception excellent, both as reviews of a particular subject and also as presentations of the latest work of a particular author.

The papers are divided into ten groups: (1) Cellular Biology; (2) Physical and Chemical Characteristics of Macromolecules; (3) Energy Transfer and Biochemical Synthesis; (4) Genetics and Replication of Protein and Nucleic Acids; (5) Biological Effects of Radiation; (6) Molecular Organization and Function; (7) Connective Tissue and Muscle; (8) Nerve; (9) Sensory Receptors and Signal Processing; and (10) Specificity in the Chemical Control of Biological Systems.

The most interesting feature of the book is that several papers by different authors may sometimes deal with the same topic and disagree with each other somewhat. The many electron micrographs of the ultrastructure of nerve and muscle preparations are of the highest quality and have been reproduced very well. The subject and author indices are quite complete. The book is a reprint in hard covers of a paperback original, and the price is quite low. Every student of biophysics (however loosely that is defined) should have a copy of the book.

MYRON L. WOLBARSHT

DIE MITOGENETISCHE STRAHLUNG.

By A. G. Gurwitsch and L. D. Gurwitsch. Veb Gustav Fischer Verlag, Jena. DM 27.65. 308 pp.; ill. 1959.

It is a surprise to see a book published on mitogenetic radiation, a very prominent subject in the late 1920's and early 1930's but seldom discussed since 1938. This volume was published posthumously.

The volume describes the physical and biological factors worked out by the Gurwitsch group on the detection and use of mitogenetic rays. Besides this, it discusses the photochemical effect of mitogenetic radiation, general characteristics of mitogenetic effects in living systems, and the use of mitogenetic radiation in the untangling of the function of protoplasm. The last subject is discussed in its relation to the degradation of molecular structures, and the radiation emitted during the processes. Furthermore, the role of this radiation during the synthetic processes in plants and animals, the radiation emitted during the process of cell division, and the role of radiation in initiation of cell division are discussed in detail. A detailed discussion of the relation of mitogenetic radiation to the function of the cancer cell and the biochemical processes involved in malignancy is given. The mitogenetic analysis of the different steps of excitation of nerves is evaluated.

This volume is interesting because it provides a kind of summary of all the work that Gurwitsch did in this field, together with its latest developments. Especially interesting is the last chapter, beginning on p. 286, which apparently was written not by the authors themselves but possibly by some other person who put the volume together. It tries to justify the book in a very broad way and to push aside the criticism that has been leveled against this work.

Since this review will probably be read by a generation of investigators who had no contact with this problem, it should be pointed out that, at the time of their discovery in the 1920's and for ten or fifteen years afterwards, mitogenetic rays were thought to be a possible key to a better understanding of cell division and cell functions. Unfortunately, the techniques described by Gurwitsch and his group did not prove to be reliable in the hands of other investigators. In addition to this, the physics of the detection of this radiation, especially in the monochromatic work where a fantastically small amount of radiation was supposedly sufficient to stimulate cells, has never really been established scientifically. The detection of this radiation by physical means has not been satisfactory even to Gurwitsch himself, who in this volume mentions again that he considers the biological detectors much more reliable than the physical detectors.

When such severe doubts remain about the existence of mitogenetic radiation, it is rather surprising that more than five hundred articles and nearly a score of books have appeared in which it is assumed to be an established phenomenon. It seems that Gurwitsch and his group feel that it is no longer necessary to prove the existence of the radiation as such, but rather that it is up to individuals who are not convinced to establish its nonexistence. Philosophically and logically this is not possible. Extensive work has been done in many laboratories to check on the existence of this radiation, but invariably the most critical investigators, so far as I know, have not been able to establish its existence. In many ways mitogenetic radiation appeals to imaginative biologists; and one would like very much to see its reality proved, even though it fits into a pattern of thinking that was very prominent twenty-five years ago. Unfortunately, objective and realistic investigators have not been able to verify this, and one comes to the conclusion that somehow the enthusiasm and imagination for which Gurwitsch was outstanding ran away with his experimental procedures.

The question then arises of why it has been possible for so many years to carry on this work and not either prove the existence of the rays or else show that it is not worthwhile to continue the work. This is a rather interesting philosophical question if one considers that, at the time this work was going on, support for basic problems in biology was difficult to obtain. These investigations did, however, receive generous support at that time, so there must have been something to justify it. The only reason I can conceive is that Alexander Gurwitsch was a man of great imagination and a tremendous amount of energy; many of the ideas that he had developed in his earlier days in cytology turned out to be quite correct. It is rather interesting that in a country like Soviet Russia, where it was difficult at the time to get funds for research because the country was very poor, people continued to support Gurwitsch solely on the basis of their respect for his integrity, imagination, and drive, even though they were not convinced that he was correct. It is unfortunate that this effort was spent on a problem so difficult to investigate rather than on something on which more definite progress could have been made. In his last chapter Gurwitsch complained bitterly about the failure of anyone else to take up his project, and indicates that he still did not see that the difficulty lay not with the idea, which has great appeal, but in the failure of other people to be able to repeat these experiments and get results of the same nature. Considering the number of oustanding people who supported Gurwitsch, it is rather sad to think that so much energy has been spent on a problem that up until now has not been brought to fruition. It might be worthwhile to have someone make an analysis to determine how one goes about scientific problems. This problem of

mitogenetic rays might turn out to be a very good one to begin with in order to see what is lacking in our scientific thinking that makes it so difficult to distinguish between problems that lead to some solution and contribute to progress in science and others that appeal to the imagination but cannot be handled by the scientific method.

ALEXANDER HOLLAENDER

PRINCIPLES OF RADIATION DOSIMETRY.

By G. N. Whyte. John Wiley & Sons, New York; Chapman & Hall, London. $7.00. viii + 124 pp.; ill. 1959.

Because of the complexity of the interactions between radiation and matter, the concepts and units of radiation dosimetry are difficult to define and are in a state of continuous evolution. The International Commission on Radiological Units and Measurements (ICRU), a body drawing its membership from radiological societies and national standardization laboratories all over the world, makes frequent recommendations concerning new units and standards. Whyte, himself a member of this body, has rendered a great service by providing an up-to-date text on the principles of dosimetry in accordance with the latest (1956) ICRU recommendations.

The first chapter of his book defines basic physical quantities such as flux, spectral distribution, intensity, and absorbed dose. These definitions are laid down with a neatness and logical precision not often found in the radiological literature. The next chapter briefly discusses the physical laws that govern the interaction of radiation with matter. The next four chapters, which constitute the core of the book, describe the measurement of X-ray spectral distributions, X-ray intensity, exposure dose, and absorbed dose. Two somewhat briefer chapters are then devoted to the dosimetry of charged particles and of neutrons; and a final chapter discusses secondary devices such as film badges and cavity chambers.

The book does not attempt to cover all of the technical aspects of dosimetry in detail, but is limited to the elucidation of basic principles and techniques. Each chapter contains a bibliography of the more important recent literature. The book thus provides an excellent introduction to the subject for the physicist or radiologist. The presentation is designed for readers with some familiarity with atomic physics and calculus; but the requirements are modest, so that the book should also be of value to a wider audience of biologists.

MARTIN J. BERGER

RADIATION: *What It Is and How It Affects You.*

By Jack Schubert and Ralph E. Lapp. The Viking Press, New York. $1.25 (paper). vi + 314 pp. 1957.

This volume joins an ever-increasing list of works designed to familiarize the public with a field of study that is described continually by popular journals and new sources all over the world. It is, however, one of the few sources of information written for public consumption about radiation and its relationship to man that is neither sensational nor political. This is not to say that the book is dull reading. It presents its information historically, with careful attention to accuracy, and is, as a result, interesting, informative reading. It would be of great benefit to present and future populations if this work were read not only by the layman but also by the practicing researcher, X-ray technician, dentist, and physician who, in many cases, not only do not know their machines and how they work but scoff at what they consider exaggerated reports of the potential damaging effects of X-rays. The reader will find in this volume a reasonable program for the use of radiation in most of its applications and an extensive bibliography, carefully arranged, from which future reading may be chosen.

TIMOTHY MERZ

PROGRESS IN NUCLEAR ENERGY. *Biological Sciences, Ser. VI, Vol. 2.*

Edited by J. G. Bugher, J. Coursaget, and J. F. Loutit. Pergamon Press, New York, London, Paris, and Los Angeles. $15.00. x + 436 pp.; ill. 1959.

This volume is the edited proceedings of The Second International Conference on The Peaceful Uses of Atomic Energy that was held in Geneva in 1958. The papers range from a study of X-ray-induced damage, to chromosome fine structure and to a study of primate metabolic responses to radiation. Details of the 1958 Geneva Conference sessions which relate to biological sciences are also included. This book contains considerable information of use to those interested in almost any facet of research on radiation-induced biological damage.

TIMOTHY MERZ

THERMODYNAMICS. *An Introduction to the Physical Theories of Equilibrium Thermostatics and Irreversible Thermodynamics.*

By Herbert B. Callen. John Wiley & Sons, New York and London. $8.75. xvi + 376 pp.; ill. 1960.

Most authors of books on thermodynamics use the following method to present the fundamentals: heat and temperature are defined operationally, the first law is stated, and then the concepts of entropy and the second law are introduced by looking at Carnot engines limping about various cycles. The postulates of the theory thus established, the consequences are then formally worked out. This traditional ap-

proach has the advantage that the entropy concept, which is difficult to understand, is made a little more palpable by some a priori justification.

However, a few authors feel that one should swallow the concepts and laws of thermodynamics at the very beginning and then justify the theory, after it is well developed, by comparison with experiment. This latter approach has the advantages of tighter logic and more rapid entry to those parts of the subject directly applicable to experiment. Callen has tried this approach, although when stating the postulates he has made them seem plausible by qualitative statistical considerations and analogues with extremum principles in other fields of theoretical physics. His novel approach provides added insight for one who is familiar with the subject, but may be difficult for one learning about thermodynamics for the first time. Yet in the Introduction the author states that the book can be used as an introductory textbook.

After introducing the principles of thermodynamics, the author presents, very clearly, some consequences and applications of the theory. He discusses the criteria for thermodynamic stability, first and second order phase transitions, extensions of thermodynamics to non-isotropic solids, and to magnetic and electrical systems.

The final part of the book is devoted to fluctuation theory and irreversible thermodynamics. Especially enjoyable is the author's presentation of how the concepts of irreversible thermodynamics are natural extensions of the concepts of equilibrium thermodynamics. In the final chapter the author shows the theory of thermoelectric and thermomagnetic effects as an application of irreversible thermodynamics.

No applications of either equilibrium or irreversible thermodynamics to systems of biological interest are discussed in this book. Yet the book will probably be helpful to biologists who are both familiar with thermodynamics and who are interested in its biological applications, since it may provide added insight into thermodynamics by stressing its inner structure and by presenting certain aspects of the subject, such as phase transitions, the thermodynamics of non-isotropic substances, and irreversible thermodynamics, that are not often found in introductory texts.

STEPHEN YEANDLE

BIOCHEMISTRY

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume 28. Edited by J. Murray Luck; Frank W. Allen and Gordon Mackinney, asso. eds. Annual Reviews, Palo Alto.* $7.00. viii + 698 pp + 1 pl.; text ill. 1959.

This volume once again serves a most unique and welcome function, that of presenting to biochemists and other scientists concise and well-documented reviews of recent advances in various fields of biochemistry. In the Preface the editors "consider that it may be timely to appraise the present status" of the series, and ask: "Does it still perform a useful function?" To this the answer, in my opinion, is an unqualified yes, since the series represents the most comprehensive and most convenient method of keeping up with the literature outside one's own field. How well each review covers the areas chosen still remains a function of the skill of each author, but the quality is generally high. This present volume covers the usual topics concerning proteins, carbohydrates, amino acids, lipides, steroids, nucleic acids and derivaties, vitamins, and nutrition. Of exceptional interest is the review on biochemistry in the USSR, the review on genetic factors, and the review on oxygenases and hdyroxylases.

EDWARD GLASSMAN

METHODS OF BIOCHEMICAL ANALYSIS. *Volume VII. Edited by David Glick. Interscience Publishers, New York and London.* $9.50. x + 353 pp.; ill. 1959.

With seven successive volumes, the series *Methods of Biochemical Analysis* has grown into a distinguished one. Volume 7 follows its predecessors in quality and arrangement of material. Two of its 8 chapters are devoted to new modifications of established physical methods. The principles of electrophoresis and specific immunochemical precipitation reactions are combined in a technique described as "immunoelectrophoretic analysis" (P. Graber). It is useful primarily in qualitative and semiquantitative analyses of proteins. The spectrophotometry of opaque and translucent materials in vivo, by using opal glass transmission and reflection techniques, is presented by one of the innovators of this method (K. Shibata).

Chemical methods for the determination of lipoprotein lipase, guanidinium compounds, heparin, and ethyl alcohol in blood and other tissues, account for 4 chapters of this volume. They are: The assay of lipoprotein lipase in vivo and in vitro (E. D. Korn); Determination of creatinine and related guanidinium compounds (J. F. Van Pilsum); The determination of ethyl alcohol in blood and tissues (F. Lundquist); and Determination of heparin (L. B. Jaques and H. J. Bell). A somewhat outdated and uncritical chapter is entitled: The determination of inositol, ethanolamine and serine in lipides (J. M. McKibbin). It is unfortunate also that one of the analytical methods

developed and presented by the author is of questionable value, as demonstrated by its lack of agreement with earlier and more recent techniques.

Methods for the detection of alkaloids in small tissue samples are of importance in pathology, criminology, and pharmacology, as well as in other scientific disciplines. A chapter entitled The Analysis of Basic Nitrogenous Comounds of Toxicological Importance (A. S. Curry) surveys this area in depth. The summary of the chapter, consisting of two gory case histories from pathology practice, attests to a broadminded editorial policy which permits each contributor a refreshing degree of freedom in the choice of the material which is presented.

CLAUDE F. BAXTER

DATA FOR BIOCHEMICAL RESEARCH.

Edited by R. M. C. Dawson, Daphne C. Elliott, W. H. Elliott, and K. M. Jones. Oxford University Press, New York and London. $10.10. xiv + 299 pp.; ill. 1960.

Here, at last, is a highly meritorious beginning toward compiling a technical handbook for biochemists much like those which have been available for the physical sciences for many years. Perhaps it is unjust to call this volume a beginning, since it should be considered a volume to supplement any good handbook of chemistry. The merits of this volume are manifold, but of outstanding advantage is the liberal documentation of the data summarized in it.

The volume devotes 177 pages to a tabular summary of information concerning compounds of biological interest. The compounds are grouped according to their chemical nature or physiological roles into the following categories: amino acids, peptides, etc.; carboxylic acids, alcohols, carbonyl compounds; phosphate esters, including nucleotides; purines, pyrimidines, and nucleosides; carbohydrates; lipides and fatty acids; steroids; vitamins; prophyrins and related compounds; chlorophylls and derivatives; carotenoids; enzyme inhibitors; metal-chelating agents; antimetabolites; drugs and pharmacologically active compounds; macromolecules; and miscellaneous compounds. This organization was adopted to facilitate the presentation of the various data particularly pertinent to each group. For example, the section on amino acids presents synonyms, chemical formulas, molecular weight, physical form, melting point, optical rotation, solubility, references to preparation, references to estimation, and general remarks for each compound. The sections on porphyrin compounds include spectral constants and notes on biological occurrence. The action, absorption, and fate of drugs are included. An index facilitates the location of all compounds included.

The volume includes a section on "enzymes commonly used as laboratory reagents," and tabulates the reaction catalyzed, substrates attacked, activators and prosthetic groups, principal inhibitors, references to sources and preparation of the enzyme, and general remarks, for each enzyme included. Also provided is a generous summary of methods for detecting compounds on filter paper, wherein the method is summarized and its merits, sensitivity, specificity, and literature references are cited. Additional brief sections are concerned with buffers and physiological media, properties of ion exchange resins, isotopic data, manometry, ammonium sulfate solutions, miscellaneous reagents and tests, acid-base indicators, etc.

The volume should prove extremely useful to any research laboratory with biochemical orientation. The reviewer has found it an invaluable supplement to a handbook of chemistry and *The Merck Index*. It is to be hoped that the volume will undergo frequent revisions in future years to maintain and extend its usefulness.

K. J. MONTY

BIOCHEMISTRY AND HUMAN METABOLISM. *Third Edition.*

By Burnham S. Walker, William C. Boyd, and Isaac Asimov. The Williams and Wilkins Company, Baltimore. $12.00. viii + 937 pp.; ill. 1957.

One of the most difficult tasks confronting the authors of biochemical textbooks is to compile an interesting and informative text with as much up-to-date material as possible, while knowing that certain sections will be out of date before final publication. In the Preface, the authors state that "an interval of three years since an earlier edition is sufficient time to cause a text to seem almost archaic in spots." This book had its 1st edition in 1952 (*Q. R. B.*, 29: 395, 1954) the 2nd in 1954, the 3rd in 1957, and is probably even now archaic in spots also, but still of great interest. No major changes have been made from previous editions. A few chapters have been modified, but the major efforts have been spent in bringing the book up to date. This book is not just a biochemistry textbook. Attempts are made to introduce biological and physiological material where it would help to clarify the chemistry—such as the topics Blood and Anemias, Cancer, Reproduction and Heredity, Infection, and Biological Approach. Indeed, even the organization into five major sections (Structure, Control, Growth, Metabolism, and Pathology) seems to be unique among medical biochemistry textbooks. However, in spite of an extensive bibliography, the text itself is not annotated, a fact which prevents its use as a reference book.

EDWARD GLASSMAN

CELLULAR BIOLOGY, NUCLEIC ACIDS AND VIRUSES. *Spec. Publ. N. Y. Acad. Sci., Vol. V.*

By V. G. Allfrey and 35 other contributors. The New York Academy of Sciences, New York. $10.00. x + 414 pp.; ill. 1957.

Cellular Biology, Nucleic Acids and Viruses consists of the papers presented at a conference held on the 7th, 8th, and 9th of January, 1957. The volume is arranged in four parts: Part I contains papers and discussions on poliomyelitis; Part II is on Nucleic Acids, Part III, on Properties Acquired by Cells Maintained in Continuous Culture, and Part IV, on the Role of Tissue Cultures in the Isolation and Study of Viruses. The papers included in the conference are, of course, too numerous to even mention in a review. Suffice it to say that anyone interested in viruses and their action, in tissue culture, or in nucleic acid research will benefit from a perusal of this volume.

TIMOTHY MERZ

ADVANCES IN SPECTROSCOPY. *Volume 1.*

Edited by H. W. Thompson. Interscience Publishers, New York and London. $12.50. x + 363 pp.; ill. 1959.

This is the first volume of new series of *Advances* which have become a new method of disseminating reviews to professional readers. The present series is "intended to cover . . . all important aspects of spectroscopy . . . relating to physics, chemistry, biology, astrophysics, meteorology and general technique." A glance at the table of contents reveals that there is at least one article to interest workers in any one of these various fields.

The review by A. Elliott is of particular interest to those working in the biological field, although it is entitled The Infrared Spectra of Polymers. The polymers include proteins, polypeptides, and cellulose, as well as polymers used in industry. A very valuable bibliography, which includes only papers dealing with the spectra of these polymers, is classified according to the polymers. The article includes discussions of microspectroscopy, polarization measurements, theoretical considerations of the vibrational spectra of macromolecules, and applications. A large part of the discussion is devoted to determinations of molecular structure by using polarized radiation. Also included are experimental details which would prove valuable to anyone interested in investigating the usefulness of this technique to his problem. An additional list of 110 references for the text is included. Some of this material has been included in other *Advances* which have been read by those interested in biological systems, and the book *Synthetic Polypeptides* was co-authored by the writer of this chapter. This chapter serves, however, to collect the information in one place.

Another review which will interest those concerned with the construction of optical instrumentation used in biological investigations is a discussion of infrared detectors (T. S. Moss). The detectors described are those which are used primarily in the near-infrared, and the use of this spectral region is currently being explored and expanded.

Additional reviews discuss spectral regions and techniques which are not used to any great extent with biological systems, but give an indication of the future use of these areas. Of particular interest is the vacuum ultraviolet (W. C. Price), for which commercial instruments have recently become available. It may be limited in its usefulness, since water solutions cannot readily be examined owing to the large absorption of water. This article will give anyone desiring to investigate this region of the spectrum a review of its present state of development. Two additional chapters deal with topics which might be valuable in special studies of biochemicals and are concerned with high resolution Raman spectroscopy (B. P. Stoicheff) and rotational isomerism about C—C bonds in saturated molecules (N. Sheppard). The remaining reviews are concerned with the spectra of polyatomic free radicals (A. D. Ramsay), the index of refraction of air (D. H. Rank), and the determination of the velocity of light (D. H. Rank).

The style of the presentation of the material, including the tables, is very clear as are the reproductions of the photographs of spectra. Each review contains a bibliography which includes references to papers in the years 1957–58. It is intended to publish the next few volumes quickly so that the present position of the most important fields of spectroscopy can be evaluated. The authors are all well-known workers in their fields and lend authority to the reviews. This series should occupy the shelves of anyone interested in spectroscopy and certainly of those working directly in any aspect of this field.

LEOPOLD MAY

MICROBIOLOGY

THE BACTERIA. *A Treatise on Structure and Function. Volume 1: Structure.*

Edited by I. C. Gunsalus and Roger Y. Stanier. Academic Press, New York and London. $13.00. xiv + 513 pp. + 11 pl.; text ill. 1960.

The editors of this new treatise propose to review comprehensively the general biological properties of bacteria in a series to consist of five volumes. This first volume, a valuable addition to the bacteriologist's library, draws largely from the recent literature in presenting some current ideas on the

structure of bacteria. The topics selected for discussion are well chosen for good coverage and a minimum of overlapping, but some topics one would desire to see included receive a bare mention. For example, serological aspects are neglected and do not appear to be provided for in later volumes (which are to cover the topics of metabolism, biosynthesis, growth, and heredity). An introduction to the antigenic analysis of cell structure, by E. S. Lennox, approaches the subject in a very practical manner and constitutes a unique blessing to all would-be immunologists; but it does not touch on the many facets of the subject that are more properly integrated with the other topics in the volume.

The presentations are, for the most part, completely fresh in approach; the volume is illustrated with fine light and electron micrographs. The focus remains almost entirely on bacteria in general, rather than on particular groups of organisms, although a good subject index makes it possible to locate references to particular mentioned organisms. Historical perspective also has been sacrificed in all but perhaps the very fine chapter, by Claes Weibull, on bacterial movement. This chapter, however, fails to point out sources which strongly complement the discussion presented (e.g., a primary supplementary source is hidden away as reference 106 in his bibliography).

In my opinion, one chapter of 110 pages on protoplasts could profitably have been condensed to less than half that amount of space; most of the minutiae presented aid little in understanding bacterial structure. It would seem that the space so saved could then have been distributed among other chapters to permit presentation of much more additional data in tabular form for quick and thorough reference. True, over 1400 literature citations are already accessible from the text, subject index, and author index; however, there have been few efforts in the volume to extract and condense from the older literature.

PHILIP E. HARTMAN

INTRODUCTION TO THE BACTERIA. *Second Edition.* *By C. E. Clifton. McGraw-Hill Book Company, New York.* $7.50. xiv + 558 pp.; ill. 1958.

Revision of this text has been accomplished without loss of emphasis of the fundamental aspects of bacteriology. On the contrary, the book has been brought up to date in many areas, including sections which should be of considerable value to those who wish to stress the elements of physiological and biochemical bacteriology. In this respect, the text is an exceptionally fine book for use in classes where the students have a background in organic chemistry.

The new edition is arranged much like the first (*Q.R.B.*, 26: 435. 1951), with 14 chapters devoted to the basic principles of bacteriology, followed by 10 chapters on the practice of bacteriology in various non-medical and medical areas. Clifton has succeeded in his purpose, that of surveying the field of bacteriology "in such a manner as to introduce the student not only to descriptive bacteriology, but also to the modern concepts of the how and the why of bacterial behavior."

PAUL A. HARTMAN

AN INTRODUCTION TO BACTERIAL PHYSIOLOGY. *Second Edition.*

By Evelyn L. Oginsky and Wayne W. Umbreit; drawings by Evan L. Gillespie. W. H. Freeman and Company, San Francisco. $7.50. xii + 443 pp.; ill. 1959.

As an elementary introduction to aspects of bacteriology which daunt the average undergraduate, the first edition of this book (*Q. R. B.*, 30: 86. 1955) proved of great pedagogic value. Its engaging qualities, notably the simple exposition, the breezy style which minimized difficulties, and the excellent illustrations, have been preserved in the second edition. The subject matter extends beyond bacterial physiology sensu stricto to include chapters on cytology, genetics, and bacteriophagy. Indeed, a more exact and stylistically appropriate title might be: "Highbrow Bacteriology without Tears."

In a book of this kind, it is obviously not possible to present in detail the evidence on which the conclusions are based; much has to be taken on trust by the reader. Accordingly, scrupulous factual correctness and a clear indication of where facts end and speculations begin are of vital importance. In these respects, the book is not faultless; it contains many statements which are, to say the least, contestable. For example, the following statements culled from the chapter on cytology and cytochemistry appear to be either misleading or incorrect: "... all in all, the physiological function of the cell wall is not entirely obvious; indeed, the wall may be a genetic vestigium from an unknown ancestor" (p. 31); (of bacterial flagella) "... their chemical composition is not precisely known but is presumably protein" (pp. 34–35); "... from some bacteria, after the cell has been crushed, it has been possible to obtain particles that, under the electron microscope, resemble animal mitochondria, although much smaller" (p. 38); "... if one centrifuges spores, one normally finds them to be lighter than the vegetative cell, and their refractive appearance is not an indication of greater weight or of a compressed material" (p. 39). All these statements have persisted unchanged from the first edition. It is regrettable that they were allowed to slip through the

revision and to lodge themselves in the heads of beginners.

ROGER Y. STANIER

ANTIBIOTICS. *Their Chemistry and Non-Medical Uses.*

Edited by Herbert S. Goldberg. D. Van Nostrand Company, Princeton, Toronto, London, and New York. $15.00. x + 608 pp.; ill. 1959.

Several non-medical applications of antibiotics have been developed to a considerable extent in recent years: food preservation, animal nutrition, plant disease control, and isolation and cultivation of microorganisms. These applied subjects are covered in an elementary, but thorough, fashion in this book. The discussion is confined exclusively to these economically important topics; many other topics of interest to scientists (for example, the control by antibiotics of bacteria in tissue cultures) are not mentioned. An introductory chapter, by P. P. Regna, on the chemistry of the antibiotics themselves, is a straightforward review which will be of value to workers who use antibiotics but do not deal directly with the applied subjects mentioned above. A number of miscellaneous topics (natural occurrence of antibiotics, drug resistance, mode of action, etc.) are very sketchily mentioned in a none too discriminating fashion in the introduction of the book. The final chapter, on public health problems arising from the various uses of antibiotics, would seem of especial importance. It points out that the low residual levels of antibiotics in foodstuffs, arising from the increasing non-medical uses of antibiotics, appear to be too low to induce directly deleterious side-effects in humans. Nevertheless, more thorough investigations in the future may demonstrate that wide usage of antibiotics for non-medical purposes can influence the incidence and control of human disease indirectly through widespread selection of antibiotic-resistant microbial mutants. Most chapters not only cite numerous references but include abstracts of each one in the bibliographies.

PHILIP E. HARTMAN

LABORATORY MANUAL FOR FOOD MICROBIOLOGY. *Third Edition.*

By W. C. Frazier and E. M. Foster. Burgess Publishing Company, Minneapolis. $3.60 (paper). vi + 131 pp. 1959.

Everyone who has not already done so should try Part II of Experiment 7 of this manual, using hamburger purchased at a local market as experimental material. This easily performed exercise, The Examination of Market Meats, invariably evokes awareness in the student of the bacteriological quality of certain foods. Fifty other exercises are available, which allow considerable latitude and flexibility in the planning of laboratory courses at the undergraduate level. The high school science teacher in search of experiments or projects of a microbiological nature will also appreciate this volume. On the other hand, many of the exercises are not sufficiently thought-provoking for use in graduate level courses.

Although the Second Edition of this manual appeared in 1957, a new edition was necessitated by the recent appearance of Frazier's new textbook (*Q. R. B.*, 34: 262. 1959) and the American Public Health Association book of *Recommended Methods for the Microbiological Examination of Foods* (1958). Two new exercises were added to the manual, revisions were made in several exercises, and selected references following the exercises were revised to correspond to the accompanying textbook, *Recommended Methods*, and other recent works. The appendix was expanded to include methods for the preparation of culture media and an additional section, containing student report forms for 34 of the experiments, was introduced at the end of the manual.

PAUL A. HARTMAN

HEALTH AND DISEASE

DISEASES OF LABORATORY PRIMATES.

By Theodore C. Ruch; assisted by Maryeva w. Terry. W. B. Saunders Company, Philadelphia and London. $7.50. xxvi + 600 pp.; ill. 1959.

This volume is of interest to almost anyone who works with primates. It covers all disease situations that are commonly encountered and many that are not so common. Besides being a good survey of primate disease, it is a detailed text that includes documented case histories, diagnostic symptoms, corrective procedures, and extensive lists of references at the end of every section. Ruch has produced a text that is easy to read, very informative, and useful not only to all who deal with primates but also to those working with animals whose disease conditions are similar and who have no such sources of information.

TIMOTHY MERZ

THE MEGALOBLASTIC ANEMIAS. *Modern Medical Monographs, 18.*

By Victor Herbert. Grune & Stratton, New York & London. $6.00. vi + 162 pp.; ill. 1959.

This monograph covers most of the clinical aspects

of vitamin B_{12} and folic acid deficiencies. The etiology of these diseases is discussed at length, in so far as the adult pattern is concerned. The pediatric aspects, which have recently aroused great interest, are only touched upon lightly. The biochemical interpretation of the deficiency state is discussed rather briefly, particularly the function of the folinic acid coenzymes.

The book is well written, excellently documented (over 600 references), and easy to read. The author's enthusiasm frequently shows through and is entertaining to the reader. Occasionally he expresses opinions that might be open to question—as when he criticizes some microbiological assay methods which in the hands of experienced research workers have been satisfactory, provided their results are interpreted correctly.

The section on the clinical picture is well written. The book is a valuable survey of the accumulated knowledge of the author and of many prior workers and can be recommended with confidence. Students, general practitioners, and specialists all will find it useful.

LOUIS K. DIAMOND

THE NEW CHEMOTHERAPY IN MENTAL ILLNESS. *The History, Pharmacology and Clinical Experiences with Rauwolfia, Phenothiazine, Azacyclonol, Mephenesin, Hydroxyzine and Benactyzine Preparations.*

Edited by Hirsch L. Gordon. Philosophical Library, New York. $12.00. xx + 762 pp.; ill. 1958.

During the years 1954 to 1957 more than a thousand papers were published in American medical journals concerning chlorpromazine (Thorazine), reserpine (Serpasil), meprobamate (Miltown), and other "tranquilizing" or "ataractic" drugs. Although the editor of this volume has brought together a representative sample of these reports, consisting of 118 papers from 40 journals, he has reduced the value of the collection by expunging the bibliographic references from every article.

Many of the clinical studies in this volume conclude that the drugs are singularly effective in alleviating a variety of neurotic and psychotic conditions. However, a small number of careful experimental studies, employing the double-unknown placebo technique, tend to indicate that the primary effect of the agents is a reduction in overt activity and that the final effect may be a function of the patient's reaction to the evoked passivity. In a significant article Sarwer-Foner and Ogle note that behavioral pathology may increase if the restraint produced by the drug makes the patient feel more inadequate, and a number of studies find that depressed patients often become more depressed and even suicidal following the administration of the agents.

However, excited, restless, hyperactive, and aggressive patients are pacified by the drugs. Since some patients also become more amenable to therapeutic intervention after taking these agents, the therapeutic nihilism which has prevailed in our mental hospitals has been replaced by a more hopeful therapeutic milieu; and the increased attention and interest of the hospital personnel appears to be transmissible to the patients.

THEODORE XENOPHON BARBER

MOLECULES AND MENTAL HEALTH.

Edited by Frederic A. Gibbs. Published for the Brain Research Foundation by J. B. Lippincott Company, Philadelphia and Montreal. $4.75. xii + 189 pp.; ill. 1959.

Although there is a large intellectual gap between "molecules and mental health," this book analyzes the strength of some of the threads drawing the two together. It seems likely that it will be by means of many small and often indirect threads of experimental facts that this gulf will be bridged. There is another gap which often impairs the timeliness of conference proceedings such as these. The two conferences which this book reports were held early in 1958. In this rapidly changing field, such a lag, which is not unusually long, is nevertheless sufficient to depreciate much of the original value of the proceedings for those unable to attend the conferences.

This volume combines the proceedings of two conferences. The first, Amines in Relation to Brain Function and Behavior, contains a vigorous appraisal of several debatable theories. These are concerned with the possible roles of Ceruloplasmin, taraxein, and adrenochrome in mental illness. This conference also debated the relative importance of tryptophan derivatives, catechol amines, and acetylcholine in the biochemical lesion theory of schizophrenia.

The second conference, arriving at a much more harmonious consensus, concerned ACTH in the Treatment of Hypsarhythmia. The interesting aspect of this conference is that an epileptic disorder, such as this, might also contribute to the understanding of behavioral disorders and mental retardation.

Aside from a minimal number of typographical errors and the obvious limitations in the ability of a book to reproduce evidence in the form of movie film, there are few technical shortcomings in this publication. It is liberally illustrated and well edited.

EDWARD B. TRUITT, JR.

PSYCHOLOGY AND ANIMAL BEHAVIOR

INSTINCTIVE LIVING. *A Study of Invertebrate Behaviour. International Series of Monographs on Pure and Applied Biology. Division: Zoology. Volume 3.*

By Theodore Savory. Pergamon Press, London, Oxford, New York, and Paris. $3.00. viii + 90 pp.; ill. 1959.

Contributors to the literature on animal behavior, an incompatibly diverse lot, include the naturalist, ethologist, psychologist, psychoanalyst, neurophysiologist, and biophysicist. The author, Theodore Savory, is allied most closely with the naturalist and the ethologist, but he wrote this book to discuss his differences with these and all other viewpoints. The title and subtitle indicate his main thesis: invertebrate behavior, owing largely to the predominance of instinctive behavior, but for other reasons too, is rightly and necessarily a matter distinct from vertebrate behavior. Accordingly, students of the two will not achieve a common understanding. Savory's development of this theme is worthy and full of insight. His position regarding the various ways of studying behavior, however, is less clear, although much space is devoted to it. Somehow he feels that all the analytic approaches are wanting, presumably because they fail to consider the whole organism in its biological context. In other places, though, he seems to tolerate the idea that mechanistic explanations may suffice for some invertebrate behavior. The exposition of such matters, regrettably, is often less than rigorous.

The extensive use of arachnids to exemplify patterns of behavior is a refreshing feature. The illustrations, although essential to the text in places, are so sketchy and so poorly labeled that they might as well have been omitted. Yet, on the whole, this is a good little book. Savory's competent and thoughtful views are a welcome addition to the subject of behavior.

DAVID R. EVANS

COMPARATIVE BREEDING BEHAVIOR OF FOUR SPECIES OF NORTH AMERICAN HERONS. *Publications of the Nuttall Ornithological Club, No. 2.*

By Andrew J. Meyerriecks. Nuttall Ornithological Club, Cambridge, Mass. $4.60. viii + 158 pp. + 15 pl.; text ill. 1960.

After more than 3,000 hours during three seasons of intensive study of the Green Heron, *Butorides virescens*, besides supplementary observations on three other heron species, A. J. Meyerriecks has presented a vivid, authoritative report on the behavior of these birds from their arrival on the nesting grounds to the laying of the first egg. Some 40 admirable line drawings made from his field sketches and photographs clearly illustrate various attitudes and displays of his subjects. These are supplemented by 15 excellent photographs.

In contrast to many recent ethological papers, the author does not arbitrarily assign each display to a hostile, escape, or sexual "drive" or to a conflict of these "drives"; instead, he uses the term "tendency" in a "strictly descriptive" sense, and he points out that many displays cannot be pigeonholed in one definite category or another.

Eighty pages are devoted to the Green Heron and 60 to the Great Blue Heron, *Ardea herodias*, the Reddish Egret, *Dichromanassa rufescens*, and the Snowy Egret, *Leucophoyx thula*. In the third section of the book—Some Evolutionary Trends in Heron Behavior—the following subjects are discussed: sociality (with a table listing 13 species from the most solitary to the most social), polymorphism, sexual dimorphism and pair formation, the coloration of soft parts, and size and activity (smaller herons as a rule being markedly more active than large ones). Finally, a Comparative Behavior Chart shows for 10 species of North American herons the occurrence, absence, or unknown status of 61 activities, from those concerned with comfort movements and feeding techniques to a long list concerned with breeding. This will prove a most useful guide for the study of other herons.

The 5 pages of bibliography attest to the author's wide knowledge of the literature, both on herons and on ethology. This is an important book, one that deserves careful study from all serious students of bird behavior. It should serve as a model for future work.

MARGARET M. NICE

THE COMPUTER AND THE BRAIN. *Mrs. Hepsa Ely Silliman Memorial Lectures.*

By John von Neumann. Yale University Press, New Haven. $3.00. xiv + 86 pp. 1958.

Early in 1955 John von Neumann was invited to give the Silliman Lectures at Yale University during the spring of 1956. An unfortunate illness never allowed him to deliver those lectures or even to finish the manuscript which was to be the basis for his lectures. This small book is based on his unfinished and fragmentary manuscript.

The book is divided into two main parts. The first discusses the two principal types of modern computing machines, analog and digital, and their characteristics. The second part of the book discusses the brain, its functioning, and characteristics in machine terms.

It is difficult to say how much good it does to make detailed comparisons between the brain and

computing machines. Although there are some superficial analogies between the two kinds of mechanism, the differences turn out to be much more impressive than the similarities. If you are interested in such speculations, however, you will find this an interesting and well-written document.

A. CHAPANIS

RIGIDITY OF BEHAVIOR. *A Variational Approach to the Effect of Einstellung.*

By Abraham S. Luchins and Edith Hirsch Luchins. University of Oregon Books, Eugene. $10.00. xxvi + 623 pp. 1959.

Why do people repeatedly manifest patterns of behavior which are no longer useful or which are destructive and self-defeating? The authors approach this question by a thorough study of one type of experimentally induced "rigid" behavior. In the basic experiment a series of water-jug volume-measuring problems is administered. They are amenable to solution by one method. After a number of such problems have been solved, most subjects develop a "set" or *Einstellung* toward solving subsequent problems in the series by the same procedure, even though the later problems can be solved much more simply and directly by other methods. To isolate the significant variables in this selected case of "rigidity," the authors have carried out hundreds of studies over two decades and with thousands of subjects. This seems to be the most intensive and long-continued study of a single behavior pattern that has ever been attempted.

What causes rigid behavior? This study suggests that an easy answer is not available. The rigidity shown in the experimental paradigm is a function of the instructions, of the subject's previous experience with such tests, of the subject's understanding of the purpose of the test, and of numerous other variables in the situation. Furthermore, similar behavior in this situation is brought about by different factors in different subjects.

The experimental results are discussed in the light of various learning theories, and an interesting chapter is included which compares psychological rigidity with elastic deformation in physics. The volume also contains a critical review of earlier theories of "rigid behavior," including the theories to Freud, Lewin, the Gestaltists, K. Goldstein, and H. Werner.

This volume is recommended as a demonstration of how the intensive study of one isolated aspect of behavior produces results which cannot be explained by general theories, and how such a long-continued study of one phenomenon leads to ramifications not envisaged at its commencement.

THEODORE XENOPHON BARBER

PERSONALITY AND PERSUASIBILITY. *Yale Studies in Attitude and Communication.*

By Irving L. Janis, Carl I. Hovland, Peter B. Field, Harriet Linton, Elaine Graham, Arthur R. Cohen, Donald Rife, Robert P. Abelson, Gerald S. Lesser, and Bert T. King. Yale University Press, New Haven. $5.00. xiv + 333 pp. 1959.

This volume, the second in a projected series of studies on attitude and communication from the Yale psychological laboratories, presents 9 research reports by a team of investigators concerning personality factors which determine responsiveness to persuasive communications. Proposing to isolate personality characteristics that make for "general persuasibility" (defined as "a predispositional factor reflecting an individual's susceptibility to influence from many different sources, on a wide variety of topics, and irrespective of the media employed"), the investigators administered various types of persuasibility tests and personality tests to hospitalized mental patients, first-graders, and high school and college students. The data presented suggest that, in males, responsiveness to persuasive influence is directly related to social isolation and feelings of inadequacy and is inversely related to overt aggressiveness. Although females tend to be more persuasible than males, no significant correlation was found between personality characteristics and persuasibility scores in this group. Recognizing the preliminary and tentative nature of the research findings, the authors suggest that refined measures of ability to attend, to comprehend, and to evaluate are necessary to clarify the behavioral dimension under investigation.

The volume is introduced by a useful review of earlier research in the area. The concluding chapters by Hovland and Janis present an interesting theoretical discussion of possible motivational and aptitudinal factors which play a role in responsiveness to social influence.

THEODORE XENOPHON BARBER

MEASUREMENT OF SUBJECTIVE RESPONSES. *Quantitative Effects of Drugs.*

By Henry K. Beecher. Oxford University Press, New York. $12.75. xvi + 494 pp. 1959.

This volume brings together a series of important papers which have significantly affected the methods employed in studying pain responses and drug effects in man. The first section contains a thorough discussion of thermal, electrical, mechanical, and chemical methods of producing pain and of procedures used in measuring pain. Experimental work in these areas is criticized as having neglected an important intervening variable, "the reaction to pain," which stands between the stimulus and the response. However, in this context, the term *reac-*

tion to pain does not refer to overt activity, such as the withdrawal of a burned finger from a flame, but to a "mental process" which follows the original sensation. Although Beecher conceptualizes this process in terms of prior learning and in relation to the subject's conception of the significance or importance of the pain sensation, the denotations of the concept remain vague.

While discussing the "psychic reaction to pain," Beecher presents a useful summary of experimental studies which find that biologically inert chemical substances (placebos) are effective in producing "satisfactory relief" of post-operative wound pain and of terminal cancer pain in approximately 35 per cent of patients tested. The author effectively argues that experimental studies of the pain-relieving properties of drugs require a double-unknown technique employing placebo controls in which neither patient nor observer knows what agent has been administered.

A discussion of the statistical problems involved in studying the action of analgesics is followed by a critique of experimental investigations of the human pain threshold. The latter studies have failed to demonstrate consistency in pain threshold from one individual to another or even in the same individual at different times. Beecher presents sufficient data to demonstrate his contention that such studies have not controlled numerous factors which significantly influence the perception of minimal pain.

The second section of the book presents experimental investigations which attempt to quantify "subjective" responses to narcotics, barbiturates, psychotomimetics, and other drugs. This includes a study of the effect of a narcotic on hunger; quantitative studies of sedation effects and of nausea, pruritus, and experimental and pathological cough; and a comparative study of the effects of morphine, heroin, pentobarbital, and a placebo on normal subjects, chronically ill patients, and post-addicts (with the interesting finding that morphine produces dysphoria in normal persons). In discussing the psychotomimetic drugs (lysergic acid diethylamide and mescaline), the author relaxes his critical acumen. With few exceptions the experimental studies of these agents did not use the "double-blind" placebo control, and the findings presented may have been directly or indirectly a result of suggestive effects.

The volume is repetitious and could have been significantly reduced in size without loss of content by some careful editing. Although the earlier neurological work which seemed to indicate that "pain is a special sensation, served by its own apparatus" is uncritically accepted, and although the basic concept of "psychic reaction to pain" is in need of further specification, the thorough review of investigations which have attempted to establish a psychophysics of pain and the presentation of original methods for studying the effects of drugs make this volume required reading for all serious investigators in the area.

THEODORE XENOPHON BARBER

THE PSYCHOLOGY OF AFFILIATION. *Experimental Studies of the Sources of Gregariousness. Stanford Studies in Psychology, I.*

By Stanley Schachter. Stanford University Press, Stanford. $3.75. x + 141 pp.; ill. 1959.

This monograph presents a series of experiments designed to isolate factors which lead to the desire to be with others. As a test of his basic hypothesis, that anxiety leads to increased affiliative tendencies, the author induced various degrees of fear in female subjects in an experiment ostensibly concerned with electric shock. After anxiety feelings were manipulated, the subjects were asked if they preferred waiting their turn to be shocked alone or with others. The more anxious subjects expressed more gregarious tendencies in this situation than the less anxious. In other studies along similar lines, Schachter found that first-born and "only" children were more prone to show anxiety during isolation, when hungry and when threatened with pain-producing stimuli. Also, when anxiety was held constant, first-born and "only" children showed more affiliative tendencies in such threatening situations. The author relates these findings to experiments by other investigators which indicate that, when compared with individuals who were later-born children, those earlier in the birth order remain longer in psychotherapy, have less than their share of alcoholics, and perform less effectively as fighter pilots. Further studies are indicated to determine whether ordinal position in the family is a significant variable in other experimental situations.

This monograph is recommended reading for those studying the effect of primary family group relationships on later behavior and for investigators studying differential responsiveness to stress.

THEODORE XENOPHON BARBER

ON THE MYSTERIOUS LEAP FROM THE MIND TO THE BODY. *A Workshop Study on the Theory of Conversion.*

Edited by Felix Deutsch. International Universities Press, New York. $5.00. x + 273 pp. 1959.

This book is an outcome of the workshop having to do with psychosomatic problems which was conducted for several years by Felix Deutsch. The book is limited to the question of what Freud called the "mysterious leap from the mind to the body," or the theory of conversion. There is a notable group of participants from the Boston area. After

the preliminary discussion of what Deutsch calls "the riddle of the mind-body correlations," an interesting discussion follows as to whether the term "mysterious leap" is warranted. The attitude taken by Stanley Cobb and Henry Fox was fairly well accepted by the other participants, who agree that the term is, in fact, meaningless, and a semantic construction with no realistic or practical utility.

There is a survey of Freud's writings concerning the conversion process. Deutsch concludes that Freud's concept of conversion is being vastly expanded beyond its original meaning, and he appears to include in its terms the peripheral expression of all the emotional experiences with symbolic connotations. The first signs of conversion consist in a subjective appreciation of an unrest, unpleasure, anxiety; and each time the memory of this unpleasure is evoked, it brings about a transformation of the changed activity of the cell systems. Whenever the cell system chooses the "wrong way" in its defense, it will persist by repetition until a more suitable adjustment is possible.

There follows a series of papers by the participants and dealing with different aspects of the conversion process: symbolization as a formative stage of it; the role of the aggressive drives in the conversion process; conversion as process and conversion as symptom in psychosis; a psychobiological study of the conversion process in women; symptom formation and male homosexuality; and loss of sensory perception determining choice of symptom. Several of these papers are very interesting indeed, but one's pleasure in the case presentations is badly damaged by the impression left by two of the contributions: that cancer of a special organ is due to the heavy load of cathexis carried by that organ. Not to be unduly critical, it still seems that in the light of the difficulty, for example, in assessing the role of cigarette smoking in lung cancer, it is gratuitous to read cause and effect into something which may obviously be only coincidental. I am left with the feeling that theory has been permitted its own unbridled (cancerous) proliferation. In short, the physician is carried away by the beauty of his own theoretical construction. Henry Fox put the criticism more gently when he said: "Suggestive correlations between the regressive dynamic balances resulting from disturbances in the function of the ego with associated alterations in the neuroendocrine environment of tissues which became cancerous were indicated by some of the clinical observations reported in the papers we have just heard. A clear appreciation of the limitations imposed by our ignorance, however, concerning the relationship of mind and brain as well as recognition of our incomplete understanding of the physiological connections between the central nervous system and the humoral balances of the body will avoid misleading conclusions. Further investigation of symbolization, perception, and the maintenance of quantitative balances by physiological and by psychological methods *within their respective framework of observation* seem to provide the best opportunity gradually to establish the highly significant psychophysiological correlations suggested by the reports of the participants in this panel."

The book points to the need for alertness in detecting correlations between experiential factors, their symbolic meanings, and bodily processes; but the experienced physician will be most cautious about drawing premature conclusions.

WENDELL MUNCIE

A GENETIC FIELD THEORY OF EGO FORMATION. *Its Implications for Pathology. The Freud Anniversary Lecture Series; The New York Psychoanalytic Institute.*

By René A. Spitz. International Universities Press, New York. $3.00. 123 pp. 1960.

This little gem of a book constitutes an expanded version of a lecture given by the author at The New York Academy of Medicine on May 27, 1958, under the title, "Field Theory of Ego Formation and Its Implications for Pathology." To have it in book form is a welcome event for those of us who were unable to attend that lecture. Spitz here attempts a close correlation between the facts of the unfolding of the human personality, biologically speaking, and the psychic structure as laid down in Freud's teachings concerning the nature of psychic energy and the sequence of the libidinal phases on the formation of psychic structure. He describes his own observations of three successive stages of psychological development in the first year of life representing levels of increasing complexity, each one marked by the appearance of a specific variety of affective behavior. The first stage in the infant's life is one of non-differentiation, that is to say, between psyche and soma, between ego and id, between incoming stimuli. Response is indifferent; it may or may not take place. If it does take place, it can occur in any of the sectors of the body function at that age. This stage operates under the principle of tension reduction. Later on, this is followed by pleasure-unpleasure responses, but still without differentiation beyond the rudiments necessary to establish conditioned reflexes. The first change occurs at the third month of life. The indicator for this is the infant's smiling response. It is his first recognition of Gestalt, to which he reacts with this specific behavior. The individuals offering this Gestalt are interchangeable: there is not yet a true object relation, but a pre-stage of object relations from which the real thing will progressively unfold. This corresponds with Freud's argument that the infant's

visual recognition of the human face and the smiling response marks the establishment of the reality ego, establishing that "something which is present in the ego as an image can also be rediscovered in perception, that is, in reality" (Freud, 1925).

The conditions necessary for this, the establishment of the smiling response, agreed with Freud's postulate that "an essential precondition for the institution of the function for testing reality is that objects, which have been lost, have formerly afforded real satisfaction." In this first changed condition, we see the development of a rudimentary body ego, a central steering organization serving an adaptive function. Along with this rudimentary ego is the establishment of the id. In short, in this phase, the infant turns from inner to outer perception. Reality testing begins, memory traces are laid down and become available, and directed object relations begin and can be observed. From the psychoanalytic point of view, these manifest the topographic division of a psychic apparatus into a conscious and unconscious part, the differentiation of an ego and an id, and the first example of the functioning of thought process, which consists in the displacement of cathexis along memory traces.

The second change occurs somewhere after the sixth and before the tenth month, and the indicator of this is the appearance of what Spitz calls the "eight-month anxiety." Here smiling is not given to any facial image, but differentiation occurs and is mixed with signs of anxiety over unfamiliar Gestalt. The anxiety reaction varies from a bashful averting of the eyes to the hiding of the face in the blankets and to screaming and weeping. This reaction indicates that the libidinal object proper has been established. And this initiates the era in which the love object and the relations to it have begun, and the social relations are becoming more and more complex. Within a few weeks social gestures will be understood; prohibitions and commands also will be understood; space and its manipulation come into the picture. Also an understanding of the relations between things develops, so that one thing can be used as a tool for achieving another; things are differentiated from each other; discrimination between foods arises; and the affective responses undergo shadings and discrimination. Spitz points out that the first organizer is essentially and largely a matter of maturation and less so a psychological development, whereas in the second organizer of the psyche the psychological development is the more dominant. Just because of this, the second organizer is more vulnerable, and it is from this point on that abnormal developments may occur. The assumption is that one organizer leads to later ones serially and that the adequate establishment of later ones depends on the normal establishment of the preceding ones.

The third organizer of the psyche occurs at about eighteen months, and the indicator for this is the acquisition of speech—not the global words used before this time, in which single words are used to express a whole gamut of meanings, but discriminative speech as a tool for discriminative communication. Its gestural symbol is the "no-gesture" expressed by shaking the head horizontally. This initiates the implementation of defense mechanisms in their enduring form alongside of the manifestations of the anal stage. It indicates the unfolding of higher intellectual functions.

Spitz next discusses the analogies between personality development and the lessons learned from embryology, specifically the matter of increasing complexity of integrative function resting on earlier stages of more simple development; and the lessons to be learned from developmental imbalance from a psychological and embryological standpoint. The analogies are striking and indicate that when a psychological development, which is age-adequate for a given critical period, cannot take place, it will be difficult or impossible for the individual to acquire it at a later stage. In the normal unfolding of the infant, there is "maturational compliance" and simultaneous "developmental compliance." The synchronicity of these two factors is absolutely essential for normal development. By contrast, in pathological cases there is a lack of synchronicity in maturation and development. If, during a critical period, the appropriate developmental item is not forthcoming, then the maturational factors will seize on other developmental items which are available and will produce deviation. Spitz mentions the observations of von Senden on individuals born blind, whose cataracts were removed years later and for whom visual orientation was practically impossible to achieve. In fact, such individuals, after months of trying to learn it desperately, asked to be blind again. Experiments with rats point to similar conclusions. Spitz believes that similar observations can be made in regard to children: specifically, that disturbance in infantile object relations results in deficient ego formation, according to the critical period at which they occur. Spitz likens this to the observations from the field of ethology.

These three early organizers of the psychic structure, then, are of extraordinary importance for final psychological development. The author describes them as the pre-human steps on the road to humanization.

I find it difficult to convey the thrill afforded me by this little book. The author's capacity for acute observation and for theoretical deduction, his grasp

of the general field of biology and embryology, and his capacity to put this into a form which leaves the reader with the feeling of having something tangible to digest and to work with, alike stir in me the greatest admiration.

WENDELL MUNCIE

THE NEW PSYCHIATRY.

By Nathan Masor. Philosophical Library, New York. $3.75. viii + 155 pp. 1959.

In this small book the author proposes as standard treatment for the neuroses, psychosomatic conditions, depression, and schizophrenia, treatment with thyroid extract and vitamins combined with a rather direct counselling type of psychotherapy; and he gives short case reports to illustrate his method. Specifically, he gives each week intramuscular or intravenous injections of equal parts of thyroxin and vitamin B_{12}. With each meal, the patient takes thyroid extract and vitamins of the B-complex type. The dosage is said to be highly individualized, and there is no clear indication of the safe limits in the administration of the thyroid extract. Masor claims that failures by this method have been far exceeded by the successes, and that he has not been able to predict who will and who will not be able to gain relief. He notes that cases with fatigue occurring as part of the syndrome seem to have a better outlook. Relapses occur sometimes, but after four years of treatment Masor seemed satisfied that the endocrinological and metabolic approach was wholly responsible for the improvement. In many cases, psychotherapy was not necessary at all.

There are two aspects of this book about which I would have to express a negative attitude. The details of the treatment and the details of the cases are not sufficient for an outside observer to judge the usefulness of this approach. The second objection is the utterly uncritical and intemperate denunciation of all other methods used today except those closely related to the author's own. He is particularly intemperate in his criticism of all dynamic methods.

The jacket of the book claims that this is a significant contribution to psychiatry and challenges functional methods. The method may have value—and I note that others are experimenting with this procedure—but one would not be able to deduce it from the book itself. Masor offers his word backed by a minimum of evidence.

WENDELL MUNCIE

DRINKING AND INTOXICATION. *Selected Readings in Social Attitudes and Controls.*

Edited by Raymond G. McCarthy. The Free Press, Glencoe; Publications Division: Yale Center of Alcohol Studies, New Haven. $7.50. xx + 455 pp. + 16 pl. 1959.

This volume, containing some 32 separate articles and a conclusion dealing with virtually every aspect of the title, comes from the Yale Center of Alcohol Studies, and can be recommended as a very helpful source of background material in the field of social attitudes to drinking and its control.

The book is divided into 5 parts: (1) Physiological and Psychological Effects of Alcohol; (2) Drinking Practices, Ancient and Modern (including authoritative articles covering the issue within Central and South American cultures, the Far East, Russia, France, England, and Canada, as well as the classical world; (3) Drinking Practices, U.S.A.; (4) Cultural, Religious, and Ethical Factors; and (5) Controls.

It would be impossible to select any particular article as superior, for such a choice would invoke only the special interests of the reviewer. Suffice it to say that all of these articles seem to have been written on the basis of sound sociological and scientific exploration. Lugubrious memories are evoked by reading the logic of prohibition as it was set forth in its heyday. A few articles that gave special pleasure were the three following: A psychocultural analysis of the alcoholic, (Harriet R. Mowrer), Attitudes of the churches (A. T. Binkley); and Who, what, and how often? (concerning drinking practices in the United States), by J. W. Riley, Jr., and C. F. Marden.

This book has 16 plates, some dealing with ancient art depicting drinking and some with aspects not so ancient. Altogether this book is a treasury of important background information for anyone interested in alcohol, not only in its problematical aspects but also in its more general social and cultural implications.

WENDELL MUNCIE

THE ANALYSIS OF DREAMS.

By Medard Boss; translated by Arnold J. Pomerans. Philosophical Library, New York. $6.00. 223 pp. 1958.

This volume presents a phenomenological approach to dreams. The author, a professor of psychoanalysis at the University of Zürich, argues that dreaming is a "real" mode of existence and that dreams should be treated as things-in-themselves and not as epiphenomena. From the theory as presented, it is difficult to determine what if anything distinguishes dreaming behavior from waking behavior. The author does not derive testable hypotheses from the theory and does not relate his concepts to the experimental work of psychologists or physiologists. However, the first section of the book, which reviews the dream theories of Schultz-Hencke, Fromm,

Bossard, Klages, and other relatively unknown European authors, should be of some interest to American research workers.

THEODORE XENOPHON BARBER

HUMAN BIOLOGY

CIBA FOUNDATION SYMPOSIUM ON MEDICAL BIOLOGY AND ETRUSCAN ORIGINS.

Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. Little, Brown & Company, Boston. $9.50. xii + 255 pp.; ill. 1959.

The origin of the Etruscans was first discussed in detail by Herodotus, who said that they were Lydian colonists. Some 400 years later Dionysius of Halicarnassus gathered and evaluated the various views then current. Dionysius, for several reasons, concluded that the Etruscans were indigenous to Italy. Their language, at that time still spoken, and their culture were unlike that of any people with which he was acquainted, including the Lydians. Also, the Etruscans appeared to be of extreme antiquity and their settlements in Italy predated any records that Dionysius was able to obtain.

What the Etruscans themselves thought about their origin has not come down to us. We possess only a few Etruscan records. They are mainly epitaphs, building dedications, and similar short pieces. The only long work is a scroll containing part of a prayer or invocation. In one respect, our knowledge of the Etruscans is inferior to that of Dionysius. We cannot read Etruscan with any certainty. Indeed, we do not understand its structure in sufficient detail to know if it is an Indo-European language. We know much more about almost all other classical peoples and their languages. We have the Etruscan tombs with their elaborately painted walls, but the Etruscans themselves remain as mysterious to us as the prehistoric folk of Spain and Southern France who left the spectacular cave paintings as their monuments.

The problem of Etruscan origins still exists. The data available to us today can be subsumed under three theories. (1) The Etruscans are an Oriental people who came in by the sea about 700 B.C. Adherents of this theory make much of the non-Indo-European character of the language. (2) The Etruscans came from the north with the other Italian tribes. In this theory, Etruscan language is Italic in nature. (3) The Etruscans were the original inhabitants. They are autochthonous, and the Etruscan language is the remnant of a pre- and non-Indo-European language similar to the ancestors of the surviving Oriential languages.

To decide which, if any, of these theories is correct was the reason for the present book, which is a record of a symposium entitled: *The Recent Contributions of Medical Biology to Anthropology, With Special Reference to the Origin of the Etruscans.*

There are 17 formal papers and numerous discussions by the thirty-odd participants of the symposium. Archeology, anthropology, history, zoology, and human genetics are all covered in some detail. The origin of the Etruscans remains unknown, but an approach to the solution of the problem has been formulated: by a means of a study of the blood groups of all Etruscan and non-Etruscan Italian skeletal remains of the proper antiquity. An appendix gives archeologists the directions for the proper preservation of the bones, so that their blood groups can be studied. The papers in this book are all well written and interesting. Most of them report on new work. All students of Etruscology and most students of biology will find something worthwhile in this book.

MYRON L. WOLBARSHT

HUMAN DEVELOPMENT.

By Phyllis C. Martin and Elizabeth Lee Vincent; illustrated by William A. Osburn. The Ronald Press Company, New York. $6.50. vi + 541 pp.; ill. 1960.

This book, which might have been given a more revealing title, is an introduction to human biology. Written in an easy, chatty style, and very nicely illustrated, it presents the developmental anatomy, physiology, and behavior of man in a loose setting of general principles of biology. The book clearly reflects that kind of a general education course in which the "preparation for life" theme is paramount. Accordingly, there runs throughout the text a refrain of the need for happy understanding of the operation and care of the human body. With man occupying center stage at all times, the principles of biology often become only a hazy backdrop. The text seldom comes to grips with a fundamental concept; only glancing blows are struck along the way. For example, hereditary mechanisms are introduced in the second chapter and crop up periodically thereafter. Yet at no single place are the fundamental principles of genetics clearly set forth, and the mechanism of meiosis on which these principles rest so heavily is not dealt with until the second from the last chapter. Another detraction is an occasional lapse into discussions, e. g., care of baby's skin, deodorants, and menu planning, which resemble more a woman's magazine than a biology textbook. Those teachers who like and believe in the type of course to which this book is dedicated will find the book very satisfactory; those, like the undersigned, who prefer a more rigorous, disciplined approach to biology will not care for it.

T. W. TORREY